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TIMSS 2015: Influences of Student and Classroom Related Background Variables on Eighth-Grade Mathematics Achievement in Asean+3 (APT) Countries

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ACCEPTANCE

This dissertation, TIMSS 2015: INFLUENCES OF STUDENT AND CLASSROOM RELATED BACKGROUND VARIABLES ON EIGHTH-GRADE MATHEMATICS ACHIEVEMENT IN ASEAN+3 (APT) COUNTRIES, by MICHAEL NGUYEN-QUAN, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Philosophy, in the College of Education and Human Development, Georgia State University.

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TIMSS 2015: INFLUENCES OF STUDENT AND CLASSROOM RELATED BACKGROUND VARIABLES ON EIGHTH-GRADE MATHEMATICS ACHIEVEMENT IN ASEAN+3 (APT) COUNTRIES

by

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ABSTRACT

Mathematics proficiency and achievement relate to a country's future economy in many aspects. The Trends in International Mathematics and Science Study (TIMSS) serves as an international evaluation and comparison among the countries and nations around the globe. The mission of TIMSS is to provide comparative data on mathematics and science achievement on fourth- and eighth-grade students of participating countries and a collection of information in terms of students' school, teachers, and homes (Snyder, de Brey, & Dillow, 2016). While many Asian countries remain as top performers, other Asian countries perform well below the international average. Furthermore, a review of relevant and current literature on TIMSS assessments revealed that a small number of participating countries would be further included in future studies (George et al., 2016) to determine how student related, teacher and classroom related variables influence student mathematics achievement on these international assessments. The purpose of this study was to examine how student and teacher/classroom related variables influence eighth-grade mathematics scores from TIMSS 2015 data reports. Guided by several educational theoretical frameworks, the researcher rationalized and developd a conceptual framework to answer a sub-set of research questions such as to what extent do student, and teacher/classroom background variables influence eighth-grade mathematics scores across the seven Asian countries. This study examined the variances within and between classrooms using several different predictor variables for seven countries in the region, known as ASEAN Plus Three (APT). The sample comprised of 42,221 eight grade students from APT countries, which include Chinese Taipei, Hong Kong, Japan, Malaysia, Republic of Korea, Singapore, and Thailand. By utilizing multilevel modeling, several HLM models were constructed to answer whether or not predictor variables had any influences on student mathematics achievement. The study findings provided strong evidence to support the perspectives that different countries have different educational models that may work for one country but not the other.

INDEX WORDS: TIMSS 2015, mathematics achievement, ASEAN Plus Three Countries, HLM

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DEDICATION

This disseration is dearly dedicated to my family, and especially to my wife, Kinh Huynh, whose endless love and countless support have made this journey come true.

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1 THE PROBLEM

Mathematics proficiency and achievement can impact a country's future economy (Baker & LeTendre, 2005). Such influence is notable in many aspects, including the likelihood of how students pursue postsecondary education, the ability of responsible citizens making adequate income, and the capability a nation as a whole can compete in the global economy. Hence, the interest to understand such factors that may have significant and consistent associations with mathematics achievement has been frequently shared among national leaders and policy makers in the world. For that reason, various national and international assessments with mathematics and science being the major domains have been developed and established. In fact, the Trends in International Mathematics and Science Study (TIMSS) has become one of many international assessments since 1995 with an average of 60 participating countries (TIMSS 1995). Since its first day of development and establishment, TIMSS has been viewed as an international, collaborative, and supportive joint effort among the participating countries. TIMSS data provide student mathematics and science achievement scores and other contextual factors at the student, teacher/classroom, and school levels (Mullis et al., 1997).

Furthermore, international large-scale assessments for student achievements are considered to play an important role in policy making, reforming, and globalizing of education. Williams (2015) argued that the start of international education could be dated back in time, but the idea of creating and piloting a formal international assessment did not surface until after World War II. According to Williams, because more nation-states ended up breaking and gaining their independency from the European colonial empires, the political geography of the world changed; hence, the development of international education became broader. Husen and Postlethwaite (1991) asserted that the very first international large-scale assessment was developed, piloted, and compared in 1959 to examine the feasibility of educational achievement with an extensive support from the United Nations Educational, Scientific, and Cultural Organization (UNESCO). The assessment was a joint effort of scholars who believed that there was a lack of "internationally valid standards" to compare among the nations (De Landsheere, 1997). Led by Dr. W.D. Wall of the National Foundation of Education Research in England and Wales (NFER), the first international large-scale assessment, Pilot Twelve-Country Study, was developed with the purpose of UNESCO's promotion of "educational system cannot be transferred from one country to another, but ideas, practices, and devices developed under one set of conditions can always prove suggestive for improvement even where the conditions are somewhat different" (Kandel, 1959, p. 253).

Originally, the first international assessment was created in French, English, and German. It was then translated into five different languages (Finish, Hebrew, Polish, Serbo-Croatian, and Swedish) for its participating countries. Created in 1959 and data collected in 1960, the Pilot Twelve-County Study targeted 13-year-old students across 12 countries, including Belgium, England, Finland, France, Federal Republic of Germany, Israel, Poland, Scotland, Sweden, Switzerland, United States, and Yugoslavia. The assessment was categorized into five subject areas: mathematics, reading comprehension, geography, science, and non-verbal ability. Students' gender and parental background information were also collected in 1960. According to Foshay et al. (1962) and later reaffirmed by Husen and Postlethwaite (1991), the assessment had two particular goals: (1) to determine appropriate suggestions of the rational operation behind responses to such assessments from many countries, and (2) to explore the possible challenges attending large-scale international research.

Husen and Postlethwaite (1991) proclaimed that for the next 50 years after the Pilot Twelve-Country Study, another 29 international assessments of student achievement were developed and conducted by the International Association for the Evaluation of Educational Achievement (IEA), the International Assessment of Education Progress (IAEP), and the Organization for Economic Cooperation and Development (OECD). These assessments have focused on a variety of subjects including mathematics, science, and literacy. The student age was also expanded to students who attend four, eight, and twelfth grades in many countries globally. Additionally, there was an increasing number of participating countries over the 50-year period. According to IEA (2007), the number of countries that participated in the international assessment for student achievement has increased from 12 in 1960, to 19 in 1970, to 24 in 1980, to 46 in 1990, and to over 60 in 2000. Its popularity and the need to have an international educational measurement have quickly become a new trend worldwide.

The Institute of Education Sciences with the support of OECD, the Program for International Student Assessment (PISA) began in 2000 and continues its administration every three years (OECD, 2004, 2005). The target population is 15-year-old students and their proficiencies in reading, mathematics, and science literacy with emphasis on the problem solving skills and their competencies in solving problems. In 2001, the Progress in International Reading Literacy Study (PIRLS) started its first development and appearance and continues to be administered every five years. The assessment's main focus is to evaluate reading literacy of fourth-grade students. It is worth mentioning that out of the 29 international assessments developed and conducted in that time period, 13 were mathematics related assessments (IEA, 2007).

Of those 13 mathematics related assessments, the first Trends in International Mathematics and Science Study (TIMSS) was established and piloted in 1995 and continues to be administered every four years. The mission of TIMSS is to provide comparative data on mathematics and science achievement on fourth- and eighth-grade students of participating countries and a collection of information in terms of students' school, teachers, and homes (Snyder, de Brey, & Dillow, 2016). With its administration in 2007, and with 60 countries participating in the study, TIMSS has become one of the largest and most aspiring international assessments of student achievement in the history of international assessments. Unlike PISA, TIMSS specifically concentrates on the grade-specific structure and educational curriculum. In fact, more than 90% of the items in TIMSS were matched with the majority of the participating countries' curricula. The details of such process was presented in TIMSS 2007 reports:

> ... Participants provided information about various educational policies and the curriculum topics covered in their respective curriculum guidelines (intended curriculum). Inclusion in the country's curriculum, however, does not guarantee students' opportunity to learn. Just as important is what their teachers choose to teach them. The lessons provided by the teachers ultimately determine the mathematics students are taught (implemented curriculum) (Mullis, Martin, & Foy, 2008, p. 189).

Research Questions

Given the historical development of the international evaluation of educational assessment and the TIMSS goals and mission, and with the high success rate of ASEAN countries over multiple implementations particularly in mathematics, it would be of interest to examine the influences of eighth-grade mathematics achievement in the latest TIMSS 2015 in seven countries, named ASEAN Plus Three (APT) countries. Specifically, a series of two-level hierarchical linear models for each individual country will be constructed by employing the contextual and background variables at the student and teacher/classroom levels to explain the variance within and between classrooms. The research attempted to answer the following sub-set of research questions:

1. To what extent do student background variables, including student gender, self-confidence in learning mathematics, valuing of learning mathematics, liking of learning mathematics, enjoying learning mathematics, time spent on homework, and time spent in tutorial, influence eighth-grade mathematics scores from TIMSS 2015 across the seven APT countries?
2. To what extent do student home resources, including computer access, parental highest educational background, and having their own room to study, influence eighth-grade mathematics scores from TIMSS 2015 across the seven APT countries?
3. To what extent do teacher characteristics, including gender, years of experience, major of study, job satisfaction, and class size influence eighth-grade mathematics scores from TIMSS 2015 across the seven APT countries?
4. To what extent do classroom characteristics, including total number of computers, influence eighth-grade mathematics scores from TIMSS 2015 across the seven APT countries?

Study Rationale

Review of relevant and current literature on TIMSS assessments revealed that a small number of the participating countries would be further included in future studies to examine the influence of student and teacher variable upon student mathematics achievement. The existing literature suggested that researchers have a tendency to focus on the high-performing countries in the Southeast Asian region such as Hong Kong, Japan, and Singapore (Greenwood et al., 2016). In fact, results of eighth-grade mathematics in TIMSS 2015 showed that Southeast Asian countries "widened global advantage in mathematics achievement" (IEA, 2016, p. 2). Such bias presented in the international achievement studies would later result in misinterpreting the research findings and creating students' stereotypes among the countries in the same region. As a consequence, the lack of research findings has led other countries in the region and around the world to establish their educational policy decisions and implement educational reforms on research findings and educational models of Hong Kong, Japan, and Singapore.

Furthermore, the Chairman of the 16th APT Summit (2013) stated that East Asia region worked toward the "implementation of the ASEAN Plus Three Plan of Action on Education (2010-2017), which would help strengthen education cooperation and human resource development" (p. 4). In order to work toward this collaborative plan, each APT country member will need to evaluate its education policies and its educational reforms to meet the action's guidelines from the K-12 setting to higher education. Hence, such examinations of the APT countries' TIMSS mathematics scores are needed to determine how students of individual country performed as compared to their peers in the same region. Also, there is a need to examine how student and teacher background variables had influenced student mathematics achievement score in each individual APT country so that those APT countries can possibly develop a revised and improved Plan of Actions on Education for its members.

In essence, it is pivotal to examine how student-, classroom-, and school-related background variables influence eighth-grade mathematics scores from TIMSS 2015 data reports. In other words, I will examine if there are any variations in eighth-grade mathematics scores across classrooms in each APT country. The study rationale has two folds. The first aspect is to find answers to pre-existing research questions that examine how APT countries performed in TIMSS 2015 using related background variables at two levels. However, the more important task, which is the second fold, is to resolve the research issue of focusing on high performing countries and spending little to no attention to low performing countries in TIMSS assessments.

Hence, the main focus of this proposed study was to delineate the influences of eighth-grade mathematics achievement in TIMSS 2015 in seven Asian countries. More specifically, a series of two-level models for each individual country would be constructed by employing hierarchical linear modeling using student- and classroom-related variables to explain the variance within and between classrooms. In all, the purpose of the study was to examine how student- and classroom-related background variables influence eighth-grade mathematics scores in TIMSS 2015.

A Review of Prospective Theoretical Frameworks

In studies of international assessments, several theoretical frameworks have been proposed and utilized to explore and explain any direct or indirect influences on student achievement. The most common frameworks employed include Carroll's (1963, 1989) *Model of School Learning*, Walberg's (1981) *Theory of Educational Productivity*, Creemers's (1994, 2007) *Educational Effectiveness Model*, and DiPerna and Elliott's (2002a) *Model of Academic Competence*. DiPerna et al. (2002b) asserted that the aforementioned frameworks share three underlying aspects: taking into account the learners' characteristics, focusing on learning environment, and centering on the quality of instruction delivery. Furthermore, many studies have suggested that a substantial variability in student performances depends on different cognitive and non-cognitive learner characteristics (Bloom, 1974, Cronbach & Snow, 1977; Messick, 1979). In that vein, Gettinger and Stoiber

(2009) argued that the relationship between time spent in learning, quality of instruction, and student achievement has been one of many debatable topics in the field of education.

Briefly, a review of conceptual frameworks that underlie international assessment studies shows a holistic concept of student and classroom variables along with any direct or indirect effects on student achievement scores. More specifically, exploring the historical and epistemological development of Carroll's (1963) *Model of School Learning* allows me to present and provide the rationale why Carroll's model is being utilized and its relevance to the proposed study. I also examine the tenets of Carroll's model in relation to student learning in order to conceptualize an adapted model that will fit this study's purpose.

A framework provides the definition of each element in the assessments. It is a theoretical understanding that acts as a foundation to the interpretation of results and findings in any research analyses. There are several theoretical and conceptual frameworks underlying the international assessments; however, I highlight a few that play an important role in shaping the study's conceptual framework later.

Walberg's (1981) Theory of Educational Productivity. Developed by Walberg and his colleagues, Theory of Education Productivity is one of the first comprehensive models to examine what influences learning. The theory is a joint collaboration in the early 1980s. As Reynolds and Walberg (1992) asserted that the theory provided unambiguous factors that were projected to have impacts on learning outcomes. In 1987, Fraser et al., proposed three sets of nine factors that are utilized to hypothesize improvement on student achievement. The first set focuses on student aptitude-attribute factors, including (a) student age, (b) student motivation measured by personality tests, and (c) student ability or prior achievement. The second set concentrates on instructional factors, including (d) quality of instruction, and (e) quantity of instruction. The third set emphasizes on factors that stimulate educational experiences, such as (f) student home environment, and (g) classroom and school learning environment. Having said that, Walberg's model clearly indicates a difference between three sets of factors: student level, instructional level, and learning environment level. In that vein, Walberg's model could dictate the interpretations of this study's findings; however, TIMSS data reports do not fully address a full-scale of school level factors. Thus, other theoretical frameworks are explored in order to capture a full picture of how student and classroom variables influence student mathematics achievement in ASEAN+3 countries.

Creemer's (1994) Educational Effectiveness Model. Similar to Walberg's Theory of Educational Productivity, Creemers's (1994) model leans toward a nested hierarchical structure which focuses on four levels, including student level, classroom level, school level, and the context level. The purpose of Educational Effectiveness Model is to examine the impact of social economical background (SES) on student's achievement. In fact, Creemers et al. explore the direct and unidimensional connection between SES and achievement. While Walberg's and Creemers's models represent the hierarchical modeling level, Creemers's model integrates a cross level interactions between the levels and factors which Walberg does not address. However, Creemers's Educational Effectiveness Model does not fit into the purpose of this study due to the assumption underlying which exerts a mutual effect of classroom- and school-level variables on student achievement. In other words, the model concentrates more on an educational perspective on student achievement by suggesting different factors have a role in influencing the learner's performance. For that reason, it is incompatible with the study's purpose to examine the influences of student- and classroom-level variables to eighth-grade mathematics achievement score.

DiPerna and Elliott's (2002) Model of Academic Competence. Developed and built from the work of Carroll and Walberg, DiPerna et al. (2002; 2005) suggested and examined a model of student achievement using various academic background variables, such as (a) student interpersonal skills, (b) student motivation, (c) student study skills, and (d) student engagement. According to the authors, those variables are identified as non-academic skills that can impact student academic success. DiPerna et al. utilize those four student related factors in conjunction with student's prior achievement to predict student achievement. To that extent, it is impossible to utilize DiPerna and Elliot's (2002) Model of Academic Competence as a conceptual framework to examine and interpret the findings from TIMSS 2015. It is because TIMSS data sets do not provide learners' prior achievement scores from each participating country.

In all, to examine the influences of student and classroom related background variables to eighth-grade mathematics achievement in ASEAN+3 countries, I use John Carroll's (1963, 1989) *Model of School Learning*. While this model describes learning as a function of aptitude, opportunity to learn, quality of instruction, and the amount of time the student is willing to spend on learning, student-related background variables collected from TIMSS 2015 are categorized into only two measures: student-related background and student home resources. This prevents the analysis of student achievement in terms of those four factors that Carroll's model proposed. Therefore, the next few paragraphs are to present the historical and epistemological development of Carroll's model. Doing so, in turn, I will provide the rationale why Carroll's model will be used as a guide to formulate a new conceptual framework which will allow the interpretation of the effects of student-, classroom-, and school-related background variables on eighth-grade ASEAN students' mathematics achievement scores from TIMSS 2015.

Historical and Epistemological Development of Carroll's (1963, 1989) Model of School Learning. Developed and published in 1963, Model of School Learning consists of five different variable categories in learning, including aptitudes, opportunity to learn, perseverance, quality of instruction, and ability to understand instruction that help explain variations in student achievement. Carroll pronounces the constructs in school learnings are relevant to time. He believes that time plays a pivotal role in school learning. He theorizes and presents the model in a simple equation: *school learning = f((time spent)/(time needed))*. In this equation, school learning is clearly a function of the quotient between the time the learners actually spent learning to the amount of time they needed to learn in consideration of the quality of instruction and the student's ability to understand such instruction. In other words, Carroll explains that school learning is a function of time. In fact, time spent is the outcome of opportunity and perseverance (McIlrath & Huitt, 1995). Theoretically, the underlying assumption in this model is students will eventually master the concepts when they are given the time and when they are willing to devote the time needed to learn. In other words, Carroll proposed that the time spending on learning will determine how successful the learner will be.

Figure 1.1 depicted how Carroll's modeling of school learning is, in fact, "a quasi-mathematical one in which three of the five classes of variables that explain variance in school achievement are expressed in term of time" (Reeves, 2011). Those five factors are associated with student success or failure in learning including: (1) aptitude-the amount of time needed to learn under finest instructional conditions, (2) ability to master the concept, (3) perseverance-the amount of time the student engage in active learning, (4) opportunity to learn, and (5) quality of instruction. Three of the five Carroll's factors including aptitude, ability to master the concepts, and perseverance are connected to students while the other two factors are more externally related.

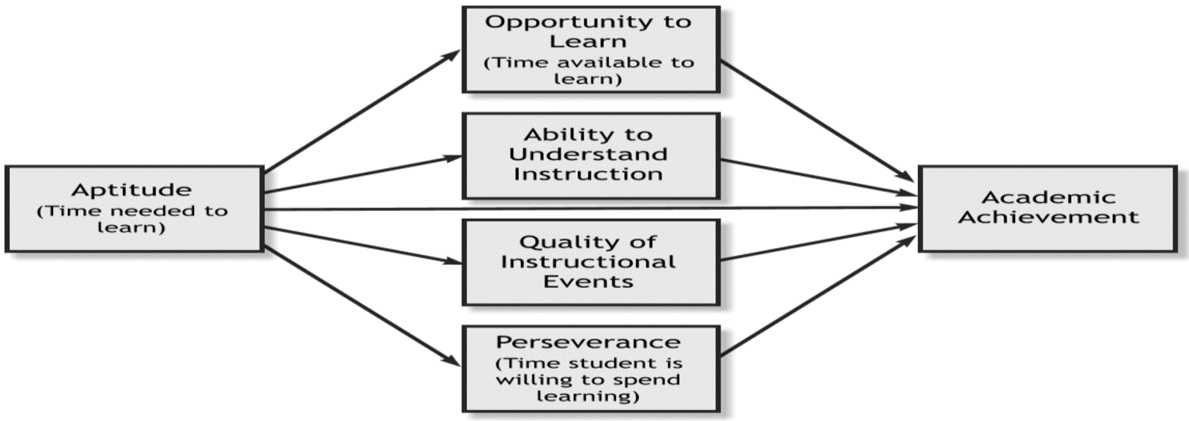

Figure 1.1 Carroll's *Model of School Learning* (1963) – Adopted from Reeves (2011) with permission.

The first tenet in Carroll's model is about aptitude which is defined as the "variable or variables that determine the amount of time a student needs to learn a given task, unit of instruction, or curriculum to an acceptable criterion or mastery under optimal conditions of instruction and motivation" (p. 18). Carroll asserts that aptitude may be influenced by other factors such as prior learning experience or genetically individual traits. However, Carroll does not believe aptitude is defined by prior knowledge but rather as time needed to learn a concept or task. Moreover, the author considers student need for time to learn is independent from teacher's related variables or the learning environment.

The second tenet in Carroll's model is about the opportunity to learn. Carroll (1963, 1989) asserts that opportunity to learn as time allowed for students to learn. He believes that this is one of a few constructs being neglected by schools. Given the aptitude construct, Carroll deliberates that opportunity to learn is often offered less than what is required in learning. He offers an explanation to the cause of less opportunity to learn is because of a large amount of material that schools expect teachers to teach and students to learn. Moreover, Carroll claims that because of the allotment of uniform in timing for learning and the ability of groupings in public education, schools have ignored the need for students to progress at their own pace.

In *Model of School Learning*, Carroll (1963, 1989) defines the third tenet, perseverance, as "the amount of time a student is willing to spend on learning the task or unit of instruction" (p. 18). In other words, perseverance is referred to the time student completes the task whether or not a long period of time or a short period of time. Taking into account of student's aptitude in learning, he or she may require a short amount of time to learn in a given task but may not take the necessary time to learn the information; Carroll (1985) refers this variable as perseverance-in-learning-to-criterion. Having said that, perseverance can be perceived as an operational description of intrinsic motivation (Carroll, 1989).

The fourth tenet in Carroll's model is about the quality of instruction as determined by how well the instructor prepares, organizes, and presents the instructional task to the learners (Carroll, 1985). With regards to student's aptitude, Carroll believes that high quality instruction should be organized and presented to students in such a way that they can learn as quickly and as efficiently as possible. On the other hand, if the task requires more time to learn, it is more likely viewed as an optimal quality of instruction. The Model of School Learning (Carroll 1963, 1989) does not specify what characterizes a high quality of instruction, but Carroll asserts that students must be explicitly told what will be learned, have sufficient contact with the learning materials, and most importantly the steps in teaching and learning need to be carefully planned and organized.

The last tenet in Carroll's model addresses the student's ability to understand instruction. Carroll considers this construct as how students infer concepts and relationships embedded in the task to be learned. Furthermore, it is also the ability to grasp the language of the instruction. While *Model of School Learning* (1963, 1989) specifies how student's ability to understand instruction can be measured using a combination of student general intelligence and verbal ability; however, Carroll does not postulate how these variables are being constructed in the model.

As defined by Carroll (1963, 1989), to achieve a particular learning target, all five variable categories in learning are related to time. However, the first three categories are directly expressed as the amount of time while the last two categories signify the amount of time the learners need to achieve a learning task. Carroll's creation of the model is to confirm the differences in each individual student and how these differences influence his or her ability to learn and the time it takes to master the task at hand. Keith (2002) stated the model was developed as a multivariate and explanatory model of how student achievement occurs. Carroll (1989) continues to refine the *Model of School Learning* by examining three other variables, including time on task, academic learning time, and quantity of instruction. In that vein, several studies have continued to examine the refinement of Carroll's model with add-on variables (Ma & Wang, 2001; Reynold & Walberg, 1992).

Speaking of how Carroll's model progresses through the years, after twenty-five years of his first published work, Carroll (1989) reviews and discusses the time factor as being one of the most mystifying complications for and against the model he had established which others had considered as mastery learning. He believes that each individual learner needs different amount of time to learn and the concept of mastery learning would increase the amount of time needed for teaching and learning. Carroll writes, "educational psychology as a science still has no adequate procedures for estimating how long as given unit of instruction will take to be learned by students with different aptitudes" (p. 27). What he means is there is no one-size fits all in education which learning and instruction are jam-packed together so every single student will be taught in the same approach. Carroll then asserts that even when time differs for the students, a "clear specification of the task to be learned" (p. 28) needs to be constant in such cases. In theory, Carroll's model sets a foundation for other researchers to continue examining the influences of set learning standards and the time allowance for student learning to student achievement (Bloom, 1974, 1976; Guskey & Gates, 1986; Pink, 2009).

Rationale toward Developing an Adapted Conceptual Framework

It can be argued that Walberg's (1981) and his *Theory of Educational Productivity* could be utilized as a backbone of this study; however, because of how TIMSS data are collected and configured for all participating countries, limited information can be gathered at the school-level variables. On the other hand, DiPerna and Elliot's (2002) focuses on student's prior achievement score, and TIMSS data lack this information. Although Creemers's conceptual framework is used in the development of TIMSS assessments, the underlying concept of mutual relationships between classroom- and school-levels on student achievement defeats the study's purpose to examine the influences of student-, and classroom-level variables to eighth-grade mathematics achievement score in TIMSS 2015.

With TIMSS being an international assessment and focusing on mathematics and science at the fourth- and eighth-grade, Carroll's model does not fully address the issue of teaching and learning mathematics. Carroll developed *Model of School Learning* with a focus on foreign language learning rather than mathematics. Hence, to find a model compatible with the study's purpose and TIMSS variables requires an adapted conceptual model that mirrors Carroll's to examine how all related variables and processes influence teaching and learning mathematics resulting in student achievement scores. In combination between Carroll's *Model of School Learning* and the hypothetical structure (Figure 1.2) which is adopted by TIMSS, I constructed a conceptual framework that serves as a conceptual framework for this proposed study. Zhao (2011) utilized TIMSS handbook to define school input and school environment as the external factors (curricula, educational policies, and resources) that ultimately trickle down and dictate what the educational process (teaching and learning), both school level and classroom level, will be. As cited in TIMSS handbook, "school's environment and organization can influence the ease and effectiveness of reaching curricular goals" (p. 75).

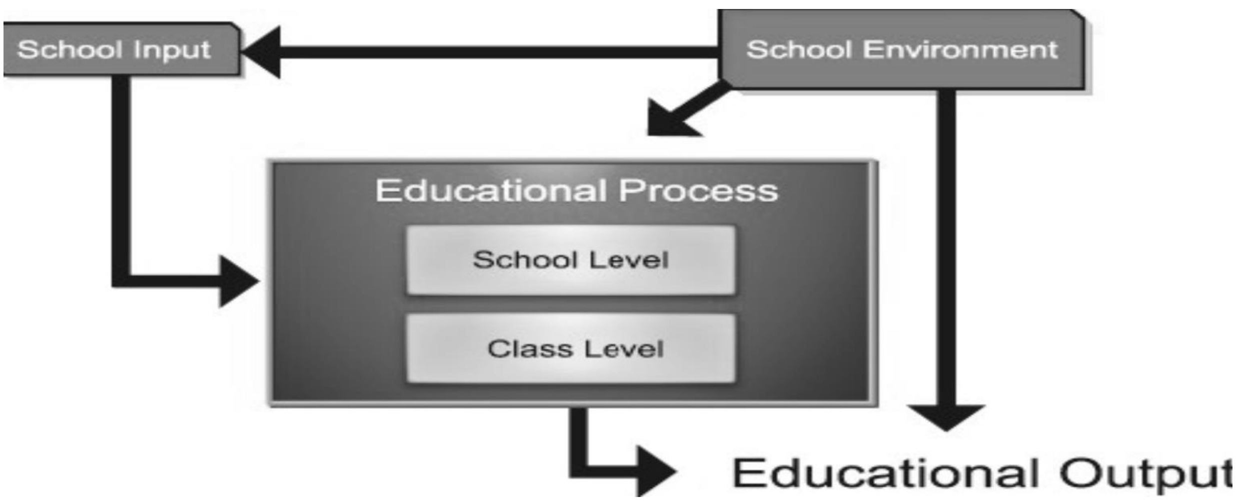

Figure 1.2. Hypothetical structure adopted by IEA in developing conceptual framework for TIMSS assessments (Zhao, 2011).

Reviews of several theoretical and empirical frameworks provide historical and epistemological backgrounds allow me to develop my own adapted conceptual framework in this study. In all, these models have been examined and tested to reflect the historical thinking of what factors influence student learning and achievement. To that extent, the adapted model will follow the same key characteristics that are found in those earlier frameworks as described in the following criteria:

(a) a model needs to include different variables related to student biological and cognitive development;

(b) the related variables need to be structured at different levels and nested;

(c) individuals respond to the context in the learning environment;

(d) learning process should support student development in terms of the related variables.

In the following section, I constructed a conceptual framework for this proposed study using the four key features listed above in combination with Carroll's *Model of School Learning*.

Adapted and Comprehensive Conceptual Framework for Mathematics Achievement

Using the four key characteristics of available models in the literature, the adapted conceptual framework will consist of three levels with student-level variables related to their background (e.g. gender, computer access at home, parental education, their own room/location for studying) and motivation (e.g. self-confidence in mathematics, valuing in learning mathematics, time spent on homework, time spent in tutorial, enjoying learning mathematics, and liking mathematics), teacher/classroom-level variables related to the quality of instruction, including: the teachers' gender, years of experience, major of study, job satisfaction, class size, and school-level variable related to opportunity, including the number of computers available in the classroom. Explained later in chapter three, the number of computers available (school-level) would be considered as the classroom-level in the analyses. Figure 1.3 depicts the adapted and comprehensive conceptual framework that will serve as a back-bone in interpretation of results and findings. Although previous theoretical frameworks have already presented various variables at multiple levels and TIMSS data provide a numerous rich information in terms of student- and classroom-related variables, the selected variables in building the structure of the adapted model presented in Figure 1.3 need to reflect “what works” in teaching and learning mathematics (Carpenter et al., 1999). Furthermore, the review and analysis of the literature provide a grounding argument as to which variables will be selected to examine the influences of student- and classroom-related variables to student achievement.

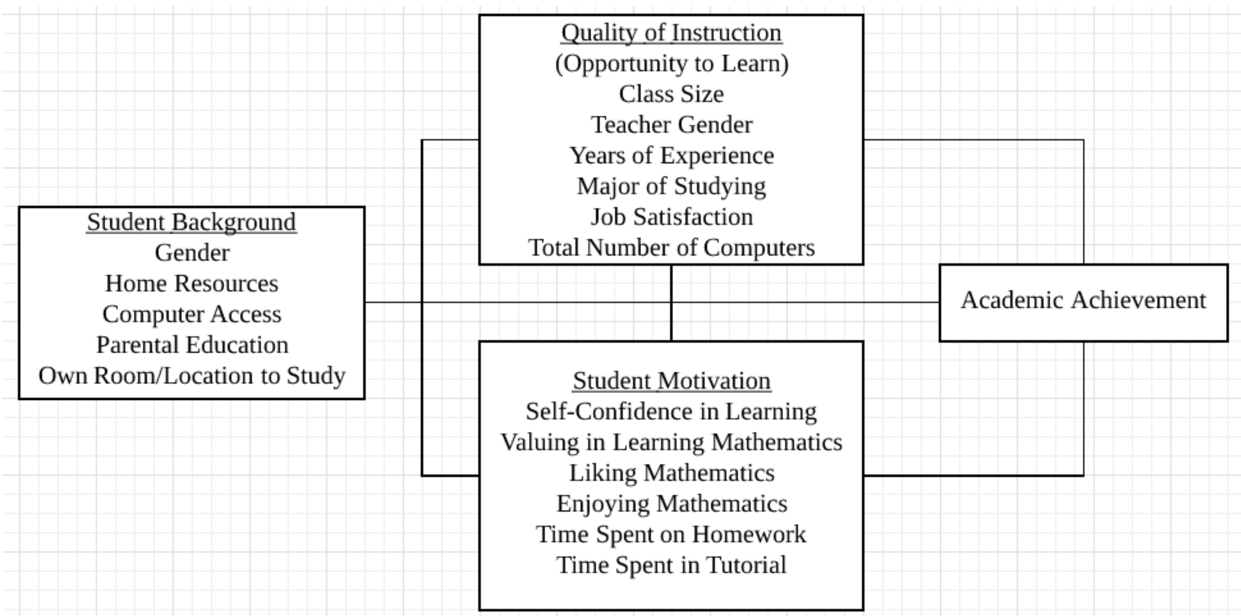

Figure 1.3. Adapted and comprehensive conceptual framework.

At the individual student level, biological and background variables play a pivotal role in examining the impacts upon the learner’s achievement. Many studies have shown gender (Bassey, Joshua, & Asim, 2011; Chowa et al., 2013; Frempong, 2010; Neuschmidt, Bart, & Hastedt, 2008), home resources with computer access (Baker, Goesling, & LeTendre, 2002; Crane, 2001; O’Dwyer, 2005; Veenstra & Kuyper, 2004; White, 1982; Yang, 2003), parental education (Else-Quest, Hyde, & Linn, 2010; Goforth et al., 2014; Pangeni, 2014; Phan & Kromrey, 2007; Yang, 2003), and own place to study (Yang, 2003) predict a positive correlation with student mathematics achievement. At the same time, Mau (n.d.) presented how student motivation can affect student mathematics achievement. In that vein, Stevenson, Lee, and Stigler (1986) had showed how much time students spend on homework and in tutorial learning mathematics can impact the student outcome.

As for classroom level variables, Stevenson and Lee (1995) suggested that teacher quality, in fact, plays an important role in predicting student mathematics achievement. In the context of this proposed study, teacher gender (Beilock et al., 2010), years of experience in teaching, major studying, job satisfaction in combination with class size and the number of total computers in the classroom will serve as relevant variables in adapting a comprehensive conceptual framework.

Significance of the Study

Regardless of its limitations, it is expected that the examination of correlates of mathematics achievement in these ASEAN+3 countries would contribute significant set of findings to the field of educational research. Moreover, the analyses to determine the influences of mathematics achievements using individual rather than between countries data produced more country-specific research results for eighth-grade students. In sum, I argue that findings from this study may provide strong evidence to support the perspectives that different countries have different educational models that may work for one country and not the other. The optimistic expectation is for other researchers to replicate this research interest with different countries in other region that participated in TIMSS 2015 assessment or with other large-scale international achievement data set. Furthermore, the findings from this study can be used to prepare other participating countries for such international assessments. At the same time, the results can also be used to design such curricula that enhances teaching and learning globally.

The examination of TIMSS 2015 database in this study may not fully answer the gap in literature, but rather be the first step in studying the eighth-grade mathematics achievement and the impact of student and classroom related background variables in seven APT countries. The purpose is to determine the variations in performance among those countries in the same region. While much of the comparative international studies have focused on the comparisons of means and medians among the participating countries, the intention of this study is focused on exploring the correlates of achievement at both student and aggregated levels (Bielick, Chandler, & Broughman, 2001).

Potential Limitations

Due to an international collection of data in 57 countries and seven benchmark entities, sampling methods (two-stage, stratified, and unequal probability), assessment design, and non-responses from students, the accuracy of the study results could be negatively affected when dealing with listwise deletion not at random. Moreover, this study examined the secondary data set from TIMSS 2015, the analyses of the data and the intepretations are limited to TIMSS database. TIMSS 2015 does not typically provide students' past achievement or aptitude scores. Hence, it is not possible to make a connection between the variables selected for this study. Additionally, some of the student related variables were collapsed to create dichotomous variables for ease of the interpretations and in line with the current literure, there exist limitations in addressing and answering the influences of these predictors upon the student mathematics achievement score. Last but not least, data collected for TIMSS 2015 were self-reported by students and teachers. Consequently, there exist various possibilities of bias including but not limited to selective memory, telescoping, and social desirability (Rosenberg, Greenfield, & Dimick, 2006). Hence, it is pivotal to interpret the findings with these limitations in mind.

Overview of the Study

The study utilized the data from the Trends in International Mathematics and Science Study (TIMSS, 2015) that was conducted by the International Association for the Evaluation of Educational Achievement (IEA) and maintained by the National Center for Education Statistics (NCSE). TIMSS 2015 comprised of student achievement scores in mathematics and science as well as student, teacher/classroom, school, and other background statistics for more than 580,000 participated students in fourth- and eighth-grade from 57 countries and seven benchmarking entities (IEA, 2016). More specially, the eighth-grade mathematics achievement scores, student demographic background and home resources, mathematics teacher background, and classroom information would be utilized and analyzed using two-level multilevel modeling.

2 REVIEW OF THE LITERATURE

Many believed that teaching and learning take place in the classroom and also depend on many factors. Researchers have found the process taken place in the classroom later become situated in school (Leung et al., 2006; Mullis et al., 2004). To that extent, there are several studies to examine how much of the variance in student performance contributes to school- and classroom-level differences. By using relevant factors, the proportion of variance at each level is explained in those studies. For example, student mathematics self-concept (Kiamanesh, 2004a, 2004b; Mullis et al., 1997; Mullis et al., 2000; Papanastasiou, 2008; Wilkins, 2004), attitude towards mathematics (Cooper et al., 2001; Goodykoontz, 2008; Kiamanesh, 2006), home educational resources (Bos & Kuiper, 1999; Fullarton, 2004; Howie, 2003; Kiamanesh & Mahdavi, 2008) were being used to examine and analyze. In all, findings indicated that there exists a positive association between student mathematics achievement with student self-concept and attitude towards mathematics. At the classroom- and school-level factors such as school location (Chepete, 2008), school climate (Mullis et al., 1998; Mullis et al., 2012), and school resources for mathematics (Ramírez, 2006) were also observed. The results displayed that there occurs a positive connection between student performance score with the school location and school climate.

This chapter will include four sections: (1) TIMSS research and major findings for seven APT countries in four period timeframe: 1995-2003, 2007, 2011, and 2015; (2) educational reforms based on the results of TIMSS 1999-2015; (3) common methodologies in TIMSS; and (4) findings in major studies employed Carroll's *Model of School Learning* as related to student learning in mathematics. Table 2.1 listed all seven APT countries and the years they participated in TIMSS with the exception of no recorded data for Chinese Taipei and Malaysia in 1995, and Thailand in 2003. In other words, Chinese Taipei and Malaysia did not participate in the TIMSS

1995 administration while Thailand scores were not available in 2003 (Martin et al., 2004). Following Table 2.1 is Figure 2.1 which presented the average mathematics achievement scores for all seven APT countries since its first administration of 1995.

Table 2.1
ASEAN Plus Three Countries and Their Participation in TIMSS

Countries	*1995*	*1999*	*2003*	*2007*	*2011*	*2015*
Chinese Taipei		x	x	x	x	x
Hong Kong	x	x	x	x	x	x
Japan	x	x	x	x	x	x
Malaysia		x	x	x	x	x
Republic of Korea	x	x	x	x	x	x
Singapore	x	x	x	x	x	x
Thailand	x	x		x	x	x

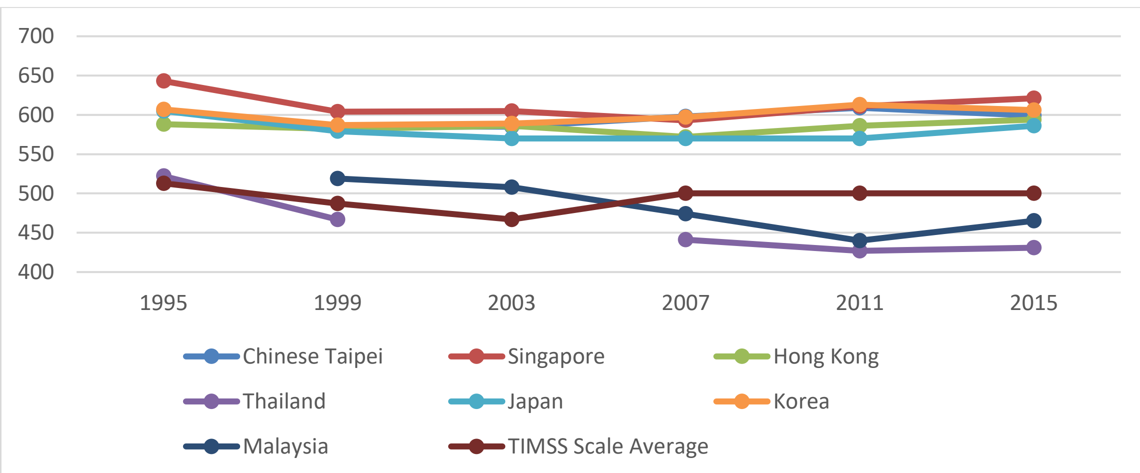

Figure 2.1. Average mathematics achievement for APT countries from 1995 to 2015.

TIMSS Research and Major Findings in the Seven APT Countries

Kellaghan (1996) argued that international comparative studies allowed legislatives to make appropriate resolutions based on the examinations of the correlates of achievement from different educational systems. However, Stedman (1997) asserted that the achievement from various countries would not be mutually comparable because of bias in choosing samples, different curricula among the participating countries, bias in purposes of the tests, and above all, bias dues to cultural differences. Hence, in this paper's section, TIMSS research and major findings for each APT country will be discussed in a way that there is no comparison between one country to another, but rather the information is used to depict the student achievement for each country throughout the TIMSS administrations.

TIMSS research and findings in 1995, 1999, and 2003. TIMSS administrations during this time period was at a foundation and refining stage. There were several international efforts to create a "universal basic education" (Ejere, 2011, p. 1). In fact, at the Dakar meeting in 2000 hosted by UNESCO, 180 countries committed to achieve "universal basic education by 2015" (p. 1). What this meant was for those countries to develop "their own national education plans-based on political will, domestic resources mobilization, and accountability" ("Education", 2008, p. 1). Therefore, for the purpose of this paper, TIMSS results and findings were grouped into 1995, 1999, and 2003-time period.

Chinese Taipei. Chinese Taipei participated for the first time in TIMSS 1999 and subsequent TIMSS administrations. Figure 2.2 presented how Chinese Taipei students performed on the TIMSS mathematics portion since 1999 as compared to the TIMSS scale average. On average, Chinese Taipei performed well above the international average score and remained as one of a few top performers.

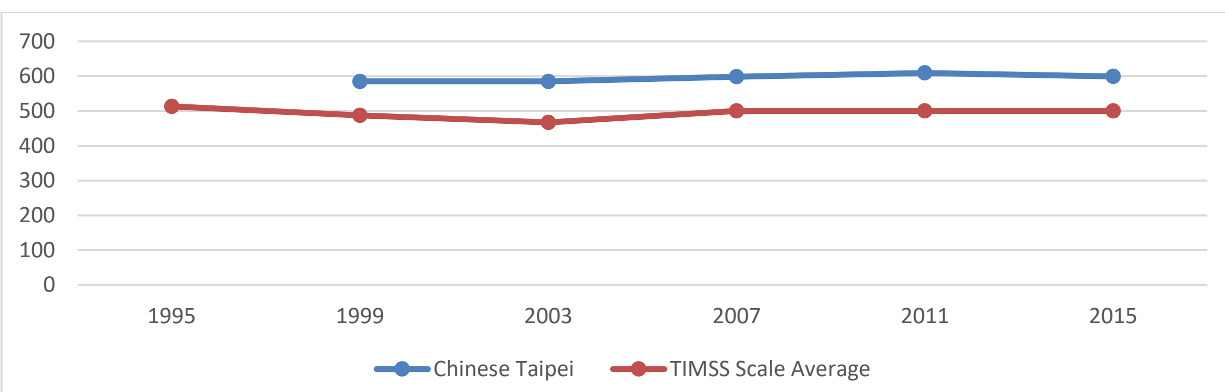

Figure 2.2. Chinese Taipei average score vs. TIMSS scale score.

The mathematics section on TIMSS 1999 contained five content areas: (1) fractions and number sense, (2) measurement, (3) data analysis, (4) geometry, and (5) algebra. According to Gonzales and Miles (2001), the TIMSS 1999 had multiple-choice, short-response, and extended-response questions. The results collected from this 1999 administration indicated that 25% of Chinese Taipei students correctly answered 92% or more of the items, 50% of the students correctly answered 81% or more of the items, and 75% of the student correctly answered 62% or more of the items (Chen et al., 2008). Chinese Taipei was one of the five Asian countries that performed well in the mathematics with an approximate of 65% of students reached the upper quarter benchmark (Gonzales et al., 2000).

In 2003, Chinese Taipei continued to show a higher performance among the leading nations participated in TIMSS in the previous administrations. Students in Chinese Taipei scored an average of 585 on the mathematics portion as compared to TIMSS scale average of 467. In other words, the students performed well above the scale average at first glance (Lin, Hung, & Lin, 2013). However, the results also indicated that there was a problem when the achievement scores were closely examined. In TIMSS 2003, there were 8% of fourth graders and 14% of eighth graders who did not reach TIMSS intermediate average score (below 475) (Mullis, Martin, & Foy, 2008). Moreover, the results showed that Chinese Taipei had the highest proportion of low-achievers (14%) among the leading nations participated in TIMSS 2003 (Lin, Hung, & Lin, 2013). That being said, the data analysis showed that the achievement gaps were widened over the years.

Hong Kong. Hong Kong participated in the first international assessment in 1995. Figure 2.3 showed Hong Kong average scores since 1995 as compared to the international average. The country's performance is still in the top five participating countries. Data collected showed Hong

Kong came fourth with an average score of 588 among the 41 participating countries in the 1995 assessment, remained in the fourth place with an average of 582 among the 38 participating countries in 1999, moved up to third position with an average of 586 among the 46 participating countries in 2003, backed to fourth place with an average of 572 among 60 participating countries in 2007, and in 2011, Hong Kong placed third with an average of 586 among 63 participating countries (Mullis, Martin, Foy, & Arora, 2012). And in 2015 TIMSS administration, Hong Kong placed fourth with an average score of 594 (Mullis, Martin, Foy, & Hooper, 2016).

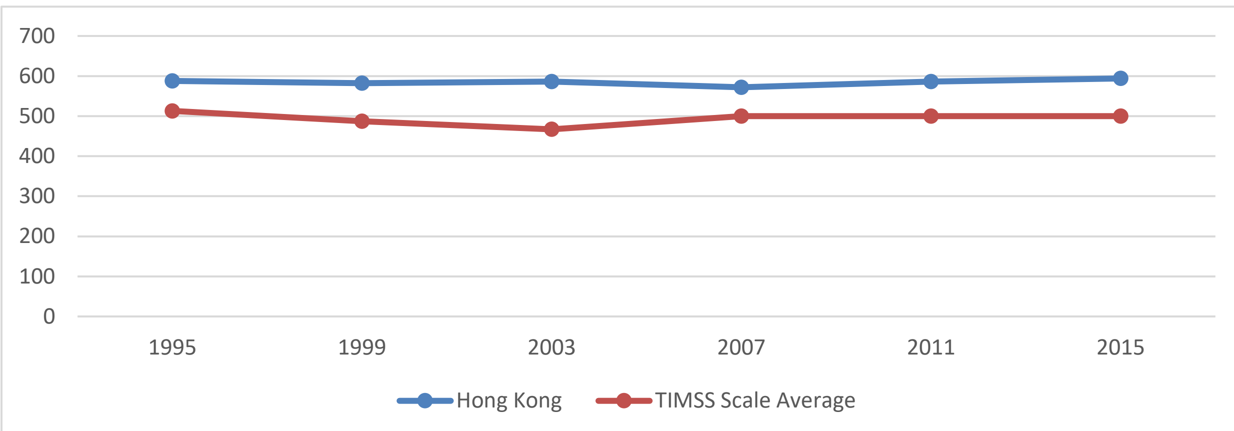

Figure 2.3. Hong Kong average score vs. TIMSS scale score.

Wang (2007) released a trend study of self-concept and mathematics achievement in a cross-cultural context and presented that there was non-monotonic change in the reciprocal relationship between self-concept and mathematics achievement. The study concluded that there was a need to enhance cross-cultural understanding in mathematics education. The author analyzed the data collected from TIMSS 1995 to TIMSS 2003 and showed that parental education levels decreased from TIMSS 1995 to TIMSS 1999, and then bounced back in the 2003 assessment. Moreover, the findings indicated an empirical bonding from parental education to student learning outcomes. Wang (2004) stated, “Hong Kong Chinese parents carried and penetrated in their home environment their attitudinal emphasis in their children’s academic success” (p. 52).

Japan. Japan joined the international assessment since its first implementation in 1995. Figure 2.4 offered how Japanese students performed on the TIMSS mathematics portion as compared to their counterparts. Japanese students remained as one of a few top performers when compared their mathematics performance to other nation-states. In fact, Japan has been among the top five performers since TIMSS first administration. Japanese students on average performed with a score of 605 as compared to TIMSS scale score of 513.

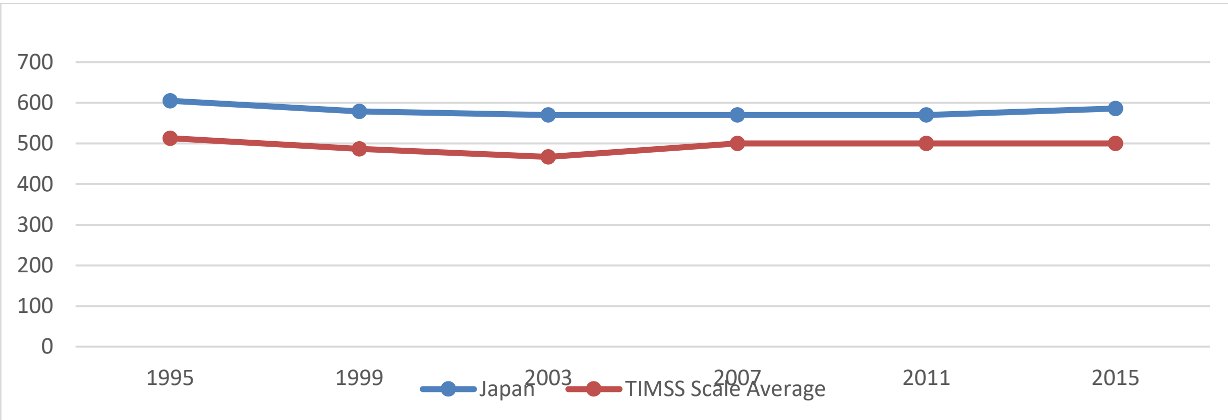

Figure 2.4. Japanese average score vs. TIMSS scale score.

Sawada (1999) released a research study, which examined the level of mathematics achievement and attitudes toward mathematics among Japanese students in TIMSS 1995 administration. The author indicated that when compared with the international average, Japanese students had high average scores in terms of test-curriculum matching analysis. At the same time, the data analysis showed that except for the geometry domain, Japanese students had better opportunities to learn when compared to other participating countries. Meanwhile, Japan also performed very well on the eighth grade mathematics assessment and place second among the other participating countries.

Continuing with its second participation in TIMSS 1999, Japan remained as one of the top performances with an average score of 579 among the participating countries. House and

Telese (2014) found that all nine mathematics confident variables were significantly correlated with mathematics achievement scores. In other words, the authors proposed that those who showed high levels of mathematics achievement indicated that they did well and learned quickly in mathematics. They found that it was significant when including all nine mathematics belief variables in the regression model. The results indicated that there was 31% of the variance in Japanese eighth-grade mathematics achievement scores explained.

In the 2003 administration, Japan continued to be among the top five performed countries with an average score of 570. House and Telese (2008) found that those students who performed well on the mathematics assessment were more likely to have positive beliefs in their mathematics ability. At the same time, the authors believed that those students who regularly worked out problems on their own tended to earn better score on the assessment. In other words, students' mathematics beliefs and classroom instructional practices were significantly correlated to mathematics achievement.

Malaysia. Malaysia did not participate in TIMSS until the 1999 administration. Figure 2.5 presented the student performance as compared to TIMSS scale score. Taking a first look at student performance, on average, Malaysian students achieved above the international average in the administration of 1999 and 2003. However, Malaysian average scores dropped below the international average scores after 2003. Compared to the participating countries in that time period in 1999, the eighth-grade students ranked 16th in mathematics (Mullis et al., 2000).

In the same vein, Liew and Pong (2000) found that among the eighth-grade Malaysian students, there existed a significant disparity among non-Malay natives and Malay natives. Furthermore, the authors also offered that there was a significant difference in mathematics achievement between genders. Their examination also exhibited that the mathematics achievement scores were impacted based on the student's educational expectations, how they perceived mathematical usefulness and reasons for doing well in mathematics. The parental educational background and the structure of family were also examined to determine the impact upon the mathematics performance. In fact, the predictors showed a significant difference among the eighth-grade students.

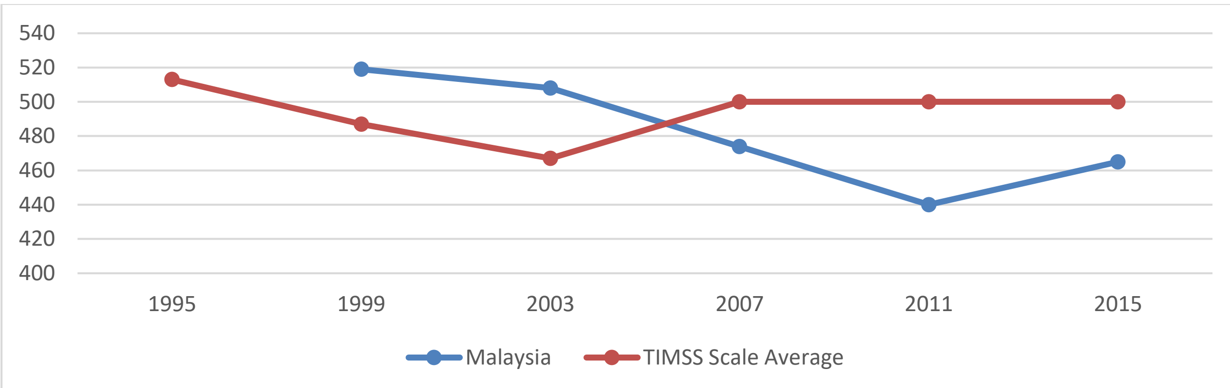

Figure 2.5. Malaysian average score vs. TIMSS scale score.

Results from the 2003 TIMSS administration indicated that Malaysia ranked 10th among the participating countries in mathematics (Mullis et al., 2004). In that vein, the mathematics achievement scores in TIMSS 2003 were actually lower than the performance scores in TIMSS 1999. Azina and Halimah (2007) released their analysis based on Malaysian TIMSS 2003. The authors found that the overall average achievement scores in five mathematics content areas were significantly higher than the international average scores. Their examination of gender and the mathematics achievement scores indicated that female students performed significantly higher on average.

Republic of Korea. Republic of Korea (South Korea or Korea) participated in the first TIMSS 1995 administration. Based on the results released from IEA (1996), Korea ranked second in eighth-grade mathematics performance with an average score of 607. The report indicated that gender differences had no impact upon mathematics achievement. At the same time, student home factors including educational resources, number of books in the home, and parental highest educational level were strongly related to the mathematics achievement. Figure 2.6 indicated how eighth-grade South Korean students performed as compared to TIMSS scale score on average. The data showed that South Korean students performed well above the international average throughout its participation in TIMSS.

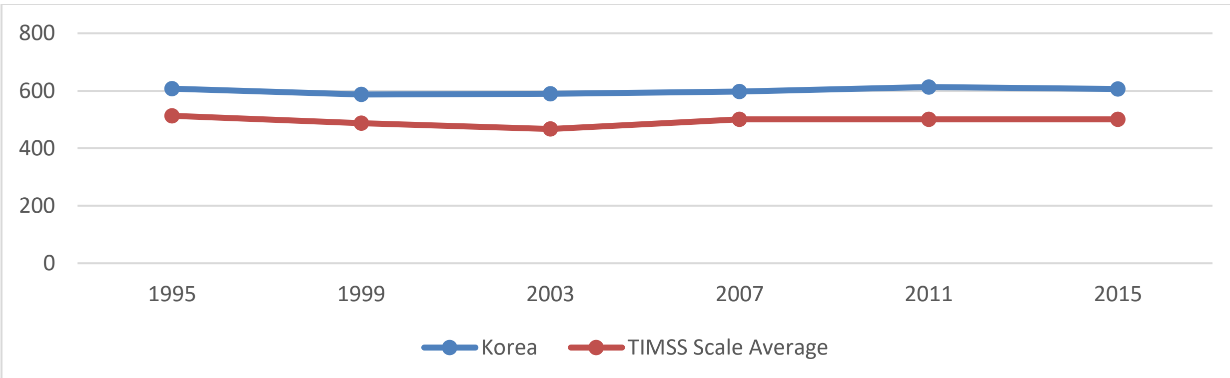

Figure 2.6. Republic of Korean average score vs. TIMSS scale score.

Despite the fact that Korea continues to rank among the top performances in TIMSS administrations, it is noted that the increase of income inequality impacted the educational inequality in South Korea (Byun & Kim, 2010). The authors utilized the TIMSS data from 1999, 2003, and 2007 to examine the relationship trends between student socioeconomic background and student achievement. They initiated that the between-school variance in student achievement explained by the school level increased over the period of 1999 to 2007, from 6.8 to 9.5, respectively. That being said, the between-school variance between 1999 and 2003 (6.8 compared to 9.0) was more dramatic than between 2003 and 2007 (9.0 to 9.5). The authors also confirmed that Korean socioeconomic background related to student achievement played a significant role. In other words, the influence of socioeconomic background on student achievement increased over the period suggesting that there existed an inequality in education in Korea during that time period.

Singapore. Singapore took part in TIMSS 1995 administration and ranked first among the participating countries for eighth-grade mathematics with an average score of 643. Just like Korea, IEA (1996) indicated that gender differences had no impact upon mathematics achievement. Furthermore, student home factors including educational resources, number of books at home, and parental highest educational level were strongly associated with the mathematics achievement. Participating in its first administration and placed first in the world in mathematics, Singapore revealed its success in an effort of moving away from its one-size-fits-all approach to schooling (OECD, 2010). This was the period of efficiency-driven phase. Figure 2.7 presented its average scores as compared to the international score on the mathematics portion. The students performed well above the international average in all TIMSS administrations. In fact, Singaporean students have been on the first and second place as compared to their counterparts.

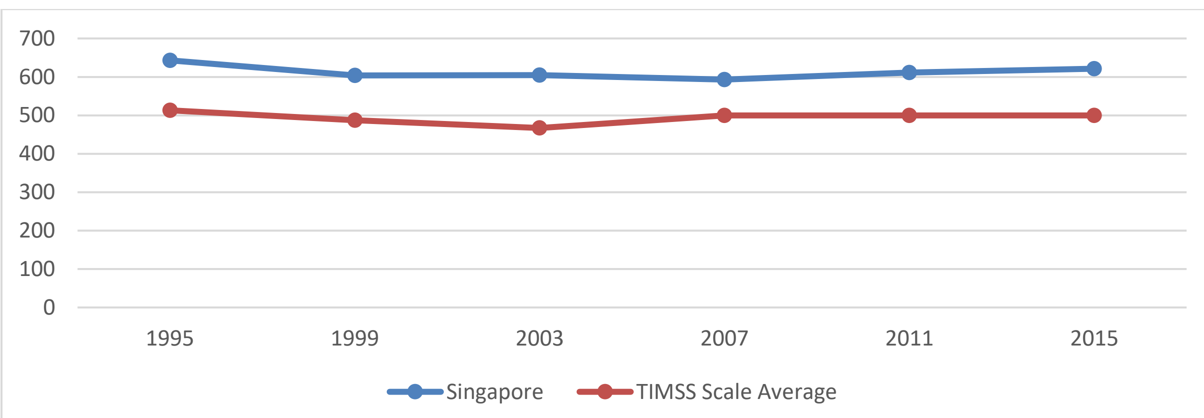

Figure 2.7. Singapore average score vs. TIMSS scale score.

Singapore continued to participate in TIMSS 1999 during its “ability-based, aspiration-drive phase” (OECD, 2010). Singapore students again performed very well and ranked first in mathematics in TIMSS 1999 with an average score of 604 (Research & Evaluation, MOE, 2000).

According to MOE, most Singaporean students were in the international top half. The report indicated that 93% of students belonged in this group. At the same time, 46% of Singaporean students reached the top 10% scores in mathematics. Using the parental and pedagogical influences and motivational variables, O'Connor and Miranda (2004) confirmed that student self-concept in mathematics had the strongest relationship for both male and female students. On the other hand, student attitude toward mathematics was only significant with male students. In another words, the authors suggested that even though female students may score high enough on the assessment, it was not necessary to say that these female students had any interests in learning mathematics or perceiving mathematics played an important role in their life.

In 2003, Singapore led the world in mathematics at the eighth-grade level with an average score of 605. According to IEA (2004), the country had significantly higher average achievement in mathematics than the rest of the participating countries. The data analysis of Singapore's TIMSS 2003 indicated that, respectively, 19.3%, 74.6%, and 5.9% of the total variance in mathematics achievement accounted for student, classroom, and school-level differences (Ghagar, Othman, & Mohammadpour, 2011). The authors later confirmed that 22.8% of the total student-level variance was accounted for by student self-concept in learning mathematics. The findings also indicated that attitude towards mathematics accounted for 5.3% of the student-level variance controlling for student self-concept in learning mathematics. At the classroom-level, the authors believed that on average, the student achievement was higher by 20.5 points when teachers described the climate of the school positively.

Thailand. Due to limited resources available at the time of research for Thailand's TIMSS 1995, general reports from IEA were utilized to show how Thai students performed on the international assessment as compared to other participating nations. The results from TIMSS

1995 showed Thailand ranked 20th among the participating countries with an average eighth-grade mathematics score of 522. IEA presented that Thai students performed relatively better in geometry at both fourth and eighth-grade. The report also disclosed that 40% or more of the students had 25 or fewer books at home as compared to students in other countries. Furthermore, 90% of the students knew what their parental highest educational level was and fewer than 10% of these students reported that their parents had completed university. Figure 2.8 showed how Thai students performed on the mathematics portion as compared to the TIMSS scale score.

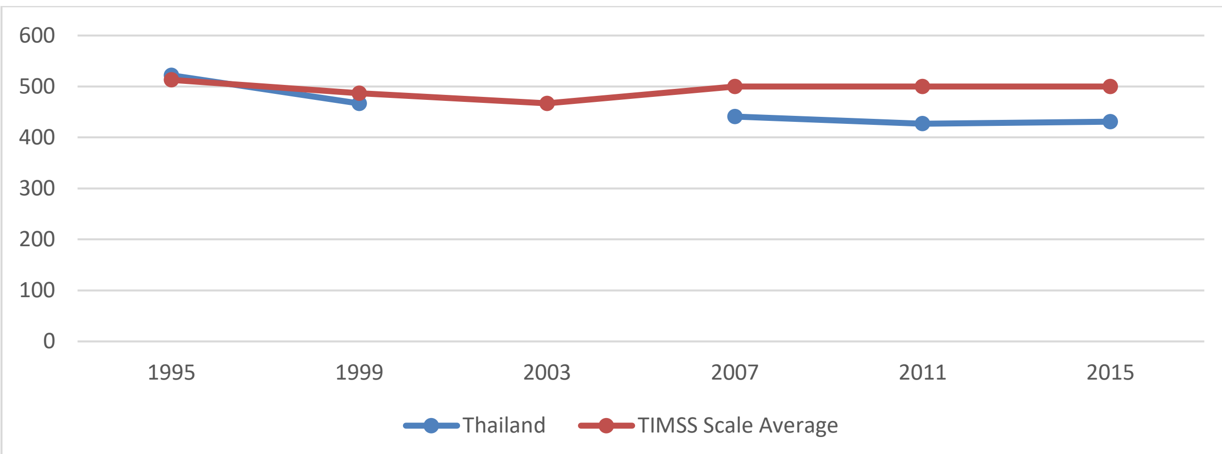

Figure 2.8. Thailand average score vs. TIMSS scale score.

Thailand ranked 27th among the participating countries in TIMSS 1999 with an average score of 467 which was below the TIMSS scale score. According to IEA, Thailand showed large decreases since its participation in 1995, and this in turn indicated that there existed sampling problems that cause an upward bias in the 1995 results. IEA also presented that male and female student achievement decreased significantly for Thailand in 1999. Thailand was also one of 16 countries that performed significantly above the international average on at least one item as well as significantly below the international average on at least one item. Thailand was one of three participating countries that had less than five percent of students who had high self-concepts in learning mathematics.

TIMSS research and findings in 2007. This time period marked an expansive trend toward internationalization and globalization. It was the time period which the push for 21st learning century was encouraged by many external factors from "the economic, political, and societal forces" (Altbach & Knight, 2007, p.290).

Chinese Taipei. Taiwanese students continued to perform well above the international average and kept its leading position in TIMSS 2007. Chinese Taipei average was 598 as compared to an international average of 500. The country continued to show a wider achievement gap among the students since 2003 (Lin, Hung, & Lin, 2013). The authors revealed that 27% of eighth graders felt confident in learning mathematics as well as 46% of this same group of students felt dissatisfied with their mathematics abilities. While Chinese Taipei continued to stay among the top five nations in terms of the student achievement scores, the students' self-confidence was the second to last among the participating countries.

Hong Kong. In 2007, Hong Kong had 3,470 eighth-grade students nested in 123 schools participated in the assessment. After four times participating in TIMSS, Hong Kong still remained as one of the top performing countries in the international mathematics and science achievement (Leung et al., 2006). Hong Kong students ranked fourth among 60 other countries participating in the assessment. The groups of researchers also presented that one-third of Hong Kong students reached well above the average benchmark. However, the study could not identify any significant differences in mathematics and science achievement between males and females. In another words, just like more than half of the participating countries, the influence of gender difference on students' mathematics and science achievement seemed to be fading.

Japan. Japan placed in the fourth position with an average score on the mathematics portion of 570 when TIMSS 2007 data and results were released. Japanese students continued to outperform others except those students who were in Hong Kong, Singapore, and Chinese Taipei. House and Telese (2012) stated that Japan tended to consistently score above the international average score. The authors examined the effects of computer activities, student mathematics beliefs, and classroom lesson activities on the mathematics achievement scores. As a result, they found that those students who earned high levels of mathematics achievement scores were reported that they had used computer at home and at school. When combing all the computer activities related variables in the multiple regression, the authors indicated that the variables were significant ($F(6,141) = 17.01$, $p < .001$) and accounted for 5.7% of the variance in mathematics achievement score on the eighth-grade assessment. For student mathematics beliefs and classroom lesson activities, there was 35.7% of the variance accounted for the mathematics achievement score on the eighth-grade assessment with all variables indicated significant effect ($F(19, 128) = 55.74$, $p < .001$).

Malaysia. Continuing on to the administration of TIMSS 2007, Malaysia dropped down to the 20th position among 50 participating countries with an average score of 474. Azina and Halimah (2012) again released their analysis based on TIMSS 2007 data. The authors found that the students' demographic background variables including gender, language spoken at home, and parental highest education were significant and accounted for the variation of mathematics achievement. The students' educational resources including the number of books at home, having a study desk, and computer at home were also examined. The findings indicated that there were significant relationships between the three educational resource variables and the mathematics achievement. The authors suggested that taking into account the significant impact of the variables, the most important variables influenced the mathematics achievement were the language spoken at home, students' self-confidence in learning mathematics, computer use, students' perception of being safe at home, and parental highest educational level.

Singapore. Singapore ranked third behind Chinese Taipei and Korea in the eighth-grade mathematics administration of TIMSS 2007 with an average score of 593. Utilizing the TIMSS 2007 database, Ng et al. (2012) indicated that students who had high positive attitude towards mathematics performed significantly well in mathematics. In other words, the authors believed that increasing students' positive attitude towards mathematics would in turn help improve mathematics achievement. Their analysis also showed that students' demographic variables including gender, language spoken at home, and parental highest educational level significantly influenced the student mathematics achievement.

Thailand. Thailand students did not participate in TIMSS 2003 administration. However, they came back in 2007 and subsequent administrations. On average, Thailand students performed lower than the international average score of 500 by 59 points in 2007, and the gap was wider in 2011 administration by 73 points as compared to the international average score of 500. Khaopa (2012) cited the deputy director of the Institute for the Promotion of Teaching Science and Technology as, "The problem over the quality of teachers was a major cause of Thailand's drop in performance in TIMSS 2011" (p. 1).

TIMSS research and findings in 2011. During this timeframe, every country continued to work for a globalized world as well as to engage with the international communities to improve their educational systems. In that sense, the U.S. Secretary of Education once said, "It is no longer enough to focus solely on ensuring that students have essential reading, writing, and mathematics, and science skills. Our hyper-connected world also requires the ability to think critically and creatively to solve complex problems, the skills and disposition to engage globally, well-honed communication skills, and advanced mathematics, science, and technical skill" (US DOE, 2012).

Chinese Taipei. Chinese Taipei continued to remain in the top five participating countries in TIMSS 2011 with an average score of 609 as compared to an international average score of 500. In fact, Taiwanese students ranked third in the 2011 assessment (Hui, 2014). The author also indicated that Chinese Taipei still had 12% of eighth-grade students who were identified as low-achievers. Moreover, Liou (2013) showed that the relationship between student self-concept of learning mathematics and achievement score increases to .71. Additionally, Cheng (2014) asserted that teaching practices, in general, played a less important role in shaping Chinese Taipei students' mathematics achievement scores as compared to other countries in the region. In another words, these results indicated that teaching mattered less for students' learning of mathematics in this nation-state when compared to Hong Kong, Japan, Korea, and Singapore.

Hong Kong. In the fifth participation of the international assessment, Hong Kong had 4,015 eighth-grade students clustered within 117 schools. Hong Kong students continued to perform well on the assessment and placed fourth compared to the rest of the participating countries. Leung et al. (2006) confirmed that the mathematics achievement in Hong Kong remained consistent for the period of 16 years (1999-2011). Furthermore, one-third of the students continued to reach the advance benchmark score. The authors also indicated that the TIMSS 2011 assessment was the first time Hong Kong experience a significant difference in mathematics achievement between the two genders in fourth grade, but showed no difference between males and females in eighth grade.

Japan. In the administration of TIMSS 2011, Japanese mathematics performance remained unchanged from the 2007 survey with an average score of 570. According to Kyodo (2012), Japan lost its fourth place from the previous survey but still ranked fifth among other 50 countries and regions. House and Telese (2012) again continued to examine the relationships between student confidence in mathematics and the achievement score for eighth-grade students. Building on results of previous studies, the authors found that all nine mathematics confident variable were all significantly related to the mathematics achievement scores. Similar to previous findings, students who performed well on the mathematics assessment also did well in mathematics. In that vein, students who were good at working out challenging problems earned higher assessment scores. From the final multiple regression model, the authors explained that the complete set of mathematics belief variables was significant ($F(9, 62) = 163.86$, $p < .001$) and 31.0% of the variance accounted for the mathematics achievement scores among Japanese eighth-grade students.

Malaysia. Malaysia continued to fall behind after its participation in TIMSS 2007. The TIMSS 2011 results showed that Malaysia ranked 26th among the participating countries based on the mathematics achievement score of 440. Due to its lower in ranking after each TIMSS administration, Lessani et al. (2014) released their findings of analysis based on TIMSS 2011. The authors found that the teacher’s familiarity with TIMSS would impact the student performance. They indicated that with the teachers being familiar with the TIMSS, the teachers would introduce the mathematics concepts from the TIMSS content domains, which could not be found in Malaysian mathematics textbooks to their students.

Republic of Korea. For TIMSS 2011, Korean students ranked first among the participating countries with an average score of 613. Using student confidence in mathematics, student engagement, and student mathematics achievement scores, House and Telese (2016) found that students who showed high levels of mathematics achievement were more likely to indicate that they knew what their teachers' expectations were. The authors also indicated that student confidence in mathematics were significant related to the student mathematics achievement in the multiple regression analysis. As a conclusion, the authors confirmed the findings indicated that student beliefs and engagement in mathematics significantly impacted and related to student test scores for eighth-grade students in South Korea.

Singapore. Singapore moved back to its first place in the TIMSS 2011 administration (IEA, 2012). Utilizing HLM models, Ker (2016) presented that the Singapore's schools were more effective in mathematics achievement. The author also indicated that major variables impacting student mathematics achievement were at the teacher level. Furthermore, at the student-level variables, student's self-confidence in learning mathematics was the most influenced variable.

TIMSS research and findings in 2015. There are limited research studies for TIMSS 2015 in those seven APT countries since results from the 2015 administration were released in 2017. However, emerging evidence shows that Singapore still stands at its first place with an average score of 621 on the eighth-grade mathematics assessment, followed by Republic of Korea with a mean score of 606, then Chinese Taipei of 599, Hong Kong of 594, and Japan of 586. Malaysia and Thailand still remain at the lower end on achievement with average scores of 465 and 431, respectively. IEA (2016) explained that those APT countries, except Malaysia and Thailand out performed 32 participating countries with a gap of 48 points, an increase of 31 points from 2011.

IEA (2016) also released the results based on the trend analyses in the past 20 years; there were no significant gender differences in mathematics achievement between eighth-grade boys and girls in Hong Kong, Japan, and Korea. IEA also indicated that Singapore "which had gender parity in mathematics achievement in 1995" (p. 2) still showed the gender gap in achievement between boys and girls over the entire 20-year trend. At the eighth grade mathematics, girls in Malaysia, Singapore, and Thailand had higher achievement as compared to boys in TIMSS 2015.

Educational Reforms Based on TIMSS Results from 1995 to 2015

Nelson Mandela once said, "Education is the most powerful weapon which you can use to change the world." In other words, education plays an important role in enhancing and developing fundamental human rights and engine for growth around the world in general and more specifically in the Southeast Asia. Having said that, by participating in the international educational evaluation, ASEAN+3 countries play a role in shaping, identifying, and implementing such education reforms to improve not only the education system in which students have access to, but also the quality of education each student receives.

Chinese Taipei participated in the past five TIMSS administrations since 1999. According to IEA (2016), Chinese Taipei went through one educational reform in 2004. While the efficacy of the 2004 reform is debatable, the main focus in this paper is to illustrate what was reformed based on the TIMSS results. Yiling (2004) wrote, "Educational system is generally a response to complex political, cultural and social concerns" (p. 2). He asserted that Chinese Taipei was not excluded from what has been going on; hence, its educational system was too conditioned by the country's history.

Despite all changes in Taiwanese educational system, TIMSS 2007 results indicated that Chinese Taipei students performed well as compared to others and remained outstanding (Taiwanese Ministry of Education, 2008). In an effort to resolve few issues, TIMSS have raised in terms of mathematics achievement and student self-confidence in learning mathematics, the Ministry of Education has focused on providing support to students in mathematics in order to enhance their interest in learning mathematics since 2001. In fact, the Ministry of Education has used TIMSS results as the primary source to evaluate the efficacy of teaching and learning mathematic in Taiwan.

Hong Kong participated in TIMSS for the past 20 years. The trend analysis of the previous results has informed the political leaders what could possibly impact on teaching and learning mathematics at the school levels. Based on the TIMSS results, the Educational Department was charged to revise and develop new mathematics curriculum in 1999 (IEA, 2016). Moreover, research projects tracking student performance were also commissioned in 2005 and 2010 to identity "areas of improvement" from 1990 to 2000s. However, Leung (2013) argued "education reform in Hong Kong has transformed the system into what is to be conceptualized as exploitative elitism" (p. 1).

Japan also participated in TIMSS for the past 20 years. The analysis of mathematics performance provides a baseline for discussion of improvements in teaching and learning mathematics. Reviewing previous literatures indicates that Japanese mathematics educational reforms were similar to the American reforms (Evan & Tirosh, 1995; Senk & Thompson, 2003). However, literatures also show a few key features in Japanese educational system. As cited in *Japan: A Story of Sustained Excellence*, Ryo Watanable once said, "Japan has national curriculum standards, or courses of study that define the content to be taught by grade and subject, and every ten years they re-devise this curriculum. Throughout the country, teachers teach based on the national curriculum standards" (p. 5). Soon right after the release of TIMSS 1995, many Western educational experts visited Japan to learn what Japanese students experienced in school so that they performed and ranked top among the participating countries (Mullis, et al., 1998).

Despite the success Japanese students have gained in the past 20 years, Japan has recently reformed its educational system in the early 21st century. While "Zest for Living" focused more on the transfer responsibilities from the central education ministry to the lower level agency, the new Fundamental Education Law concentrated in "the fear about the dilution of Japanese values" (OECD, 2010, p. 6). According to the OECD report in 2010, the first Japanese Fundamental Education Law and the reform in 2006 mainly fixated on the four principles: character building, equalities in education, democratic single school system, and free six years of elementary and three years of middle school to all students.

Republic of Korea participated in TIMSS for a total of six times since 1995. Lee (2014) believed that there were two factors contributed to why Korean students accomplished by performing well on both TIMSS and PISA in mathematics and science. He affirmed that Koreans traditionally appreciate the education as well as believe education can bring them a brighter and better life in the future. The author argued that beside the support of family in terms of how Koreans perceive education, the high performance in Korean students is also because of "its effective education system" (Lee, 2014, p. 1). In the past 60 years, there have been many initiatives the government has done to improve "the quality and equity of education" (p. 1). The government has taken into accounts of increasing the rate of school enrollment, reforming the educational system, developing national curriculum and standards, improving teaching quality, and providing high-stake standardized examinations to support "the effectiveness of the system" (p. 1).

Malaysia joined TIMSS since 1999 and has been remaining "at the bottom third of the international league table of schools" (Asadullah, 2014, p. 1). According to the author, the trend in performing below the 2011 international average in mathematics and science has become an alarming issue for the Malaysian government. In responding, the government revealed the educational reform in 2013 (ICEF, 2013). As cited in the ICEF report, the main goal for this educational reform was to "reshape how policymakers, education officials, teachers and parents deal with educational and teaching millions of our schoolchildren and preparing them and the nation for the future" (p. 1). So far, the officials have confirmed the reform's initiatives have been implemented and showed progress during the first 100 days of the 2013-2025 educational reform period.

Singapore has been participated in the TIMSS international assessment since day one and remained as one of the top performers throughout the 20-year period. According to OECD (2010), during the period of 1997 and onward, a new educational vision was created and called "Thinking Schools, Learning Nation" (p. 162). This vision was based on the Prime Minister Goh's belief. He believed that, "A nation's wealth in the 21st century will depend on the capacity of its people to learn." Lee (2008) called the educational reform and its vision as the representation of a school system focusing on creative thinking skills, lifelong learning passion, and commitment to the young. They wrote, "Learning nation is a vision of learning as a national culture, where creativity and innovation flourish at every level of society" (p. 163).

Thailand participated in TIMSS since its first administration in 1995. Thai students continue to perform at the bottom half of the participating countries and nations (Mullis et al., 1998, 2000, 2004, 2008, 2012). Thailand's 1999 National Education Act (NEA) was created in response to improve the quality of its educational system. The education act focused on the equity and student-centered in teaching and learning rather than rote learning. During this time period, Thai government created an educational plan for the period 2012-2016. However, the change in government in 2014 put a stop to its progress (OECD, 2016).

Common Methodologies in Studies on TIMSS

Understanding of how schools, classrooms, and teachers affected students' outcomes has been debated for several decades. At the same time, advances in the field of technological and educational research have positioned multilevel modeling as one of the most powerful analysis tools in examining the effects of different hierarchical variables. In that vein, O'Dwyer (2002) believed that the potentiality of multilevel modeling allowed policy decisions being made by understanding "how formal education is affected by schools, classrooms, teachers, and changes that occur over time" (p. 359). In that vein, Grilli et al. (2014) reiterated that the multilevel modeling approach allows researchers to fully comprehend "the residual correlation between pairs of outcomes at both hierarchical levels" (p. 2). The authors believed that using this approach will create a full picture of student performance and the impact of background variables to student outcomes. Grilli et al. once again confirmed Yang et al. (2002) methodological perspectives which indicate that a multivariate model "is a well-established tool" (p. 2) because it accounts for "correlated responses at levels where dependencies of observations occur" (Ma, Ma & Bradley, 2008).

Furthermore, the sampling design in TIMSS which employed a two-stage stratified procedure (Mullis, 2000) limited the number of levels that can be modeled. The methodology chapter would address as to why the number of levels can be modeled. Snijders and Berkhof (2007) believed that if the researchers ignore this sampling design in analyzing the data, the interpretations of the findings might be inaccurate. For that reason, hierarchical models have been found as common methodologies in major quantitative research in regard to TIMSS data; O'Dwyer (2002) acknowledged that the TIMSS sampling design presented only a two-level model that could be used to address the variances within and between classrooms. The author suggested that although a two-level model is useful, the analysis does not accurately reflect the variances in the outcome of within-classroom, between-classroom, and among-school components. In another words, the two-level models do not fully reveal the effects of the hierarchical variables "at the classroom variable independently of the school level" (p. 360).

Findings in Major Studies Employed Carroll's Model of School Learning as Related to Student Learning in Mathematics

To many, mathematics has been considered a challenging subject to master in school in all grade levels. Taking into accounts of those variables defined in Carroll's model, students who have low aptitude are the results of their own perception of mathematics being difficult. Furthermore, the quality of instruction, such as planning and delivering the instructional materials, plays a role in making students loose interest in learning mathematics. For those reasons, students who achieve lower than their counterparts in mathematics may have experienced either one or both events. However, review of literature and empirical studies will provide a full-scale picture of what student- and classroom-related level variables actually influence student achievement in mathematics.

Gender. In many empirical studies, gender and student beliefs or motivation have been dominantly considered as the two factors that have influences on student achievement. Traditionally, the notion of male performs better on the mathematics assessments has been a subject to scrutiny in several research studies that utilized TIMSS student achievement scores. In studying TIMSS 1995-2003, Neuschmidt et al. (2008) claimed that male students perform better than female students in Hong Kong, Japan, Korea, and Singapore, but there exist no significant changes in regard to gender differences in overall student mathematics achievement scores. However, when adopting the regression approach (Gonzalez & Mile, 2001) and using the jackknife replication procedure for sampling errors (Martin & Kelly, 2004), the difference between male and female achievement changes in favor of female students. More specifically, Korean male students performed better in TIMSS 1995, but then decreased to marginally higher than female students in TIMSS 2003.

On the other hand, Meelissen and Luyten (2008) explored and examined the influence of gender difference on the learning situations in mathematics. They investigated the gender gap by analyzing mathematics achievement and student attitudes from TIMSS 2003 pertaining to fourth-grade Dutch students. The analysis of the data presented that male students had higher levels of self-confidence than female students. However, they looked deep into the analysis and found, "girls from higher socioeconomic background have more confidence in their mathematics abilities than do girls from lower SES background, and that SES appears to have little influence for boys" (p. 91).

In another study, Louis and Mistele (2011) examined the relationships between student mathematics achievement scores, gender, and self-efficacy. They utilized TIMSS 2007 report and employed ANOVA and MANCOVA statistical approaches to determine if gender impacted the overall achievement scores in mathematics. Their findings indicated that male students exhibited higher levels of self-efficacy than their counterparts. However, the results presented that the overall mathematics achievement scores did not reflect any gender differences among male and female students. In fact, these findings were contrary to Neuschmidt's (2008) results in the previous paragraph.

Student beliefs or motivation. Many believe that successful achievement lies in how individuals perceive and motivate themselves in learning. Using TIMSS 2003, House (2003) examined the relationship between student self-beliefs and mathematics achievement scores among Hong Kong eighth-grade students. The results presented a significant relationship between student beliefs and achievement. House asserted that those who enjoyed learning mathematics and believed mathematics was important tended to perform higher than others. At the same time, those who felt mathematics was boring would achieve a lower test scores.

Furthermore, House (2005) continued to examine TIMSS 1999 mathematics data among Japanese eighth-grade students. He reaffirmed his previous results that showed a significant connection between student beliefs and achievement. In an examination of TIMSS 2003 among the Native American eighth-grade students, House (2009) again obtained similar results showing significant relationship between student beliefs and achievement. He stated that those who enjoyed learning mathematics tended to perform better on the test. In contrary, those who perceived mathematics negatively and lacked self-efficacy tended to achieve lower.

Using TIMSS 1999 data report, Hammouri (2004) examined the relationship between student-related motivational variables to achievement in Jordan eighth-grade mathematics. Employing a structural equation modeling, Hammouri found that student's perception of the importance of mathematics and student's attribution of success had a significant positive relation to achievement. In that vein, Liou (2010) analyzed TIMSS 2007 for his doctoral dissertation and found that student motivational attitudes for learning mathematics had a consistently positively relation to mathematics achievement.

Home-related factors. Several studies have proclaimed the influence of home-related variables to student achievement (Baker, Goesling, & LeTendre, 2002; Crane, 2001; O'Dwyer, 2005; Veenstra & Kuyper, 2004; White, 1982; Yang, 2003; Nyarko, 2010). More specifically, Yang (2003) examined the impact of home possession on student achievement in mathematics from 17 countries that participated in TIMSS 1999. He found that home educational resources were strongly related to academic achievement. In that vein, O'Dwyer (2005) analyzed the influence of student home background variables to eighth-grade students in 20 participating countries in TIMSS 1995 and 1999. She asserted that 15 out of 20 countries in 1995 and 14 out of 20 countries in 1999 showed a statistically significant correlation between student achievement and student home background variables.

Parental education level. Quite a few researches have looked at the influence of parental educational level to student achievement. Crane (2001) examined how parental educational level can impact their children' mathematics scores. Crane asserted that depending on the parental education level, the children would receive extra support at home as well having opportunity to learn, including tutoring services and conducive learning environment at home. In line with Crane, Pangeni (2014) claimed that students whose parents are educated to a higher level will have better access to education resources that aid the development of mathematical thinking and skills. This, in turn, will help the students succeed in learning.

Moreover, analyzing TIMSS 2003 data report for Turkish eighth-grade students, Yayan and Berberoglu (2004) found that there was a positive connection between parental educational level and student achievement in mathematics. In that vein, Schreber (2002) had found that the higher the parental education level was, the better the student achievement would be among the

American students from TIMSS 1195 report. More recently, Yoshino (2012) initiated that the parental educational level positively correlated with student mathematics achievement among American and Japanese students from TIMSS 2007 data.

Quality of instruction. Demonstrated in the literature, quality of instruction is considered at the classroom-related variables, including teacher gender, teacher education, teaching experience, job satisfaction, and class size (Darling-Hammond & Youngs, 2002; Akiba, LeTender, & Scriber, 2007; Chepete, 2008; Kaplan & George, 1998; Rice, 2003; Wayne & Youngs, 2003; Wilson, Floden, & Ferrini-Mundy, 2002). Researchers believe that the quality of instruction plays an important role in predicting student achievement. Using the NAEP report, Darling-Hammond (2000) claimed that teachers whose certification in the subject field predicted higher levels of student achievement in mathematics. This is in line with what Goldhaber and Brewer (1997) found. Both asserted that teachers who were certified in the field of mathematics tended to produce students with better performance as compared to those with no mathematics certification. Nye, Konstantopoulos, and Hedges (2004) later supported this finding by suggesting teacher certification positively impact student achievement.

Class size as part of the quality of instruction may also have impacted student achievement. The findings in Project STAR (Word et al., 1990) reiterated the implementation of class size reduction starting in kindergarten and first grade displayed a prominent student achievement. Shin and Radenbush (2011) later determined reducing class size would increase student achievement in reading, mathematics, and listening in grades K-3. Moreover, they found that the influence of class size did not differ much between schools. Using the same Project STAR, Ding and Lehrer (2010) claimed that smaller class size had a positive impact upon student achievement. The results showed a statistically significant effect on student achievement. The effect of class size on student achievement from TIMSS data report has also been analyzed. Breton (2014) found that increasing class size in Columbian fourth-grade classrooms resulted in a significant drop in achievement scores. More specifically, Breton found that one student increase in class size would result in a .03 standard deviation drop in test scores. At the same time, when reducing the class size to 20 or less students, student achievement increased by 12%.

The influence of class size on student achievement appeared again in Pong and Pallas (2001) who analyzed TIMSS 1995 data report for Hong Kong, Korea, and Singapore. Taking into accounts of student gender and background variables, a hierarchical linear modeling was used to determine the student-level and classroom-level impact. The results show that class size in these Asian countries was higher and students also performed higher as compared to other participating countries. However, when the least-square regression was employed, the results suggested that class size only influenced student achievement depends on the school system (Wobmann & West, 2006).

In summary, several educational factors are associated with student achievement. Ranging from student background, student beliefs and motivational factors, parental educational level, student home resources, to teachers' qualification and certification, and class size, each variable plays a role in determining how students learn and perform in mathematics. The proposed study adapts Carroll's Model of School Learning as its foundational framework to conceptualize a framework that will work its way into the interpretation of the research questions. Using the five identified classes from Carroll's model (e.g. aptitude, opportunity to learn, perseverance, quality of instruction, and ability to understand instruction), a new and adapted conceptual framework will be used to correspond with the gaps that the literature has identified as well as the available variables from TIMSS 2015 provided.

At the student-level, related factors include student gender, student home resources, computer access at home, parental educational level, and having own room/location to study. Moreover, student-related variables consist of motivational factors such as student self-confidence in learning mathematics, student valuing in learning mathematics, student enjoying learning mathematics, student liking mathematics, time spend on homework, and time spent in tutorial. The classroom-level related factors comprise of teacher gender, teaching experience measured by years of service, teacher certification and qualification, teacher job satisfaction, the number of available computer in classroom and class size. The predictor outcome will be the eighth-grade mathematics student achievement score from TIMSS 2015.

Chapter Summary

The economic growth and decline in the past 20 years around the world has played a role in shaping each individual education system worldwide. The 21st century has brought many challenges and opportunities for many countries in the world as well as those in the Asia-Pacific. At the conference organized by UNESCO in 2012, the world leaders presented an education development called "Toward EFA 2015 and Beyond – Shaping a New Vision for Education." Their foci were on the issue of demographic change and migration, socio-economic trends, technological advancement, climate change and environment degradation, and enhanced integration and interconnection.

Stated in *ASEAN State of Education Report* (2013), differences between the education systems may reflect the economical differences among the APT countries. The administration of TIMSS in the region presented that the language differences do not imitate the economic development, but rather relate to the historical development among the countries. Overall, recent and trending TIMSS mathematics and science achievement showed that out of the seven APT countries, five of them always make the top performer list while Malaysia and Thailand remain in the bottom half of the list.

The examination of TIMSS 2015 database in this study may not fully answer the gap in literature, but rather be the first step in studying the eighth-grade mathematics achievement and the impact of student and classroom related background variables in seven APT countries. The purpose is to determine the variations in performance among those countries in the same region. Much of the comparative international studies have focused on the comparisons of means and medians among the participating countries. However, it is not the intention of this study, but rather be informative in exploring the correlates of achievement at both student and aggregated levels (NCES, 2001).

3 METHODOLOGY

The purpose of this study was to examine four research questions that explore the influences of student and teacher/classroom related variables on eighth-grade mathematics achievement in ASEAN+3 countries. In order to determine these influences, data from the TIMSS 2015 eighth-grade mathematics achievement scores and responses to student and teacher background questionnaires were used. This chapter summarized the research design and methodology for this quantitative research. The chapter also includes the research content, participants, instruments used in the data collection, procedures used in the study, a procedure for data analysis, definitions of the variables being used in the analysis, and a summary of the methodology used.

The question of how student and teacher/classroom related variables influence student achievement is a complicated one. Many seem to disagree at many levels on how students perform based on the student background, teacher background, and classroom setting. Hence, the study attempted to address the set of four research questions:

1. To what extent do student background variables, including gender, self-confidence in learning mathematics, valuing of learning mathematics, liking of learning mathematics, enjoying learning mathematics, time spent on homework, and time spent in tutorial, influence eighth-grade mathematics scores from TIMSS 2015 across the seven APT countries?
2. To what extent do student home resources, including computer access, parental highest educational background, and having their own room to study, influence eighth-grade mathematics scores from TIMSS 2015 across the seven APT countries?

3. To what extent do teacher/classroom characteristics, including gender, years of experience, major of study, job satisfaction, and class size influence eighth-grade mathematics scores from TIMSS 2015 across the seven APT countries?
4. To what extent do classroom characteristics, including total number of computers influence eighth-grade mathematics scores from TIMSS 2015 across the seven APT countries?

It is also notable that the students were sampled and the teachers were not. Teachers' responses were then derived to correspond to students' information. Therefore, the research questions used can only be generalized to students and not teachers or schools.

Participants

Population. The sample for this study comprises of 44,229 eighth-grade students nested in 1401 classrooms in seven APT countries. Table 3.1 presents the number of students and the number of nested classrooms in TIMSS 2015 by country. The participants of the TIMSS 2015 were defined as the international desired target population. Using United Nations Educational, Scientific and Cultural Organization (UNESCO) International Standard Classification definition of primary school, all students who enrolled in the eighth year of formal schooling were part of the target population. On average, students had a minimum age of 13.5 years to be considered as part of this group (Olson et al. 2008).

According to LaRoche, Joncas, and Foy (2016), TIMSS 2015 utilized a two-stage random sampling design. Within the first stage, a sample of schools was drawn proportionally to their size (PPS) so that one or more intact classes of students were selected from each of the sampled schools in the second stage. Selected schools were later stratified by arranging them intro groups that share common features including region of the country, source of funding, language of instruction, level of urbanization, socioeconomic indicators, and school performance on national examinations. The authors presented that the purpose of this stratification was to improve the efficiency of the sample design that in turn helping the estimates more reliable, to utilize different sample designs to particular groups of schools, and to warrant a proportional representation of specific groups of schools in the sample.

Table 3.1
Number of Eighth-Grade Students and Number of Nested Classroom in TIMSS 2015 by Country

Country	*Number of Students (Level-1)*	*Number of Classrooms (Level-2)*
Chinese Taipei	5734	183
Hong Kong	4249	120
Japan	6375	144
Republic of Korea	5547	170
Malaysia	9726	276
Singapore	6116	321
Thailand	6482	187

For the second sampling stage, within each sampled school, one or more intact classes were selected with equal probability of being chosen using systematic random sampling method. LaRoche, Joncas, and Foy (2016) added that due to the nature of unreliable estimates for small sample size, a minimum class size (MCS) was required for each individual country to adhere in selecting the intact classes. Those small intact classes were combined to create a pseudo class for the purpose of sampling. Since TIMSS focuses more on students' curricular and instructional experiences, intact classes of students were sampled rather than individuals from fourth- and eighth-grade classrooms.

In sum and as explained in their brief TIMSS 2015 report, LaRoche, Joncas, and Foy (2016) addressed that each individual country defined its national target population and then used the TIMSS two-stage random sampling method to select a representation of schools and students presented in the data collection process. Due to the connection between students, teacher/classroom, and school, the selection of teachers and school principals was then determined based on the selection of students.

Study Context. For this study, seven APT countries were selected from the TIMSS 2015 eighth-grade mathematics database. The criteria used in the sample selection were because of the participating countries' stratification into geographic region in the TIMSS 2015 database. These Asian countries had a similar number of student participants for eighth-grade mathematics assessment. At the same time, their cultures and educational system are somewhat similar to each other. Moreover, tracing back to each individual country history, Malaysia and Singapore were once colonized by Great Britain, Chinese Taipei and Hong Kong were once occupied by Japanese and Great Britain, respectively, and now parts of China, Republic of Korea and Japan were once influenced by the Chinese, and Thailand was invaded by the Japanese. Since the end of World War II, each country prospers in different directions. Furthermore, as described in the context and definition of terms in the next section, these seven countries are grouped under a regional organization called ASEAN+3 (APT).

To better understand the selected participating countries for this research, a brief profile for each individual country was drafted. These brief profiles including relevant information such as geographic location and size, population, ethnic groups, official language, political system, government impact upon school systems, economic systems, and most importantly, the educational issues and reforms. It is worth to mention that the collective information in this profile was selected from multiple resources in the period of 2015-2016. At the same time, in cases where 2015-2016 information was not available, the most up-to-date data was included.

Chinese Taipei. Geographically, Chinese Taipei is located off the southeast coast of China apart from the mainland as a 13,974 square-mile island (Magaziner, 2016). Due to a long historical sensitiveness over the statehood between the mainland China and Taiwan, Taiwan is claimed as one of many Chinese provinces and home to approximately 23 million people (National Statistics of Republic of China (Taipei) [NSRC], 2016). The central educational authority is the Ministry of Education of the Republic of China. Since there exists a conflict of identifying Taiwan as *a de facto* independent nation, this study will examine Chinese Taipei as one entity participating in the TIMSS 2015 survey and assessment.

According to NSRC (2016), Chinese Taipei consisted of several ethnic groups such as Taiwanese (including Hakka) (84%), mainland China (14%), and indigenous (2%). The official language is Mandarin Chinese while there is a portion of population still uses Taiwanese (Min) and Hakka dialects nowadays. A mixture of 93% of Buddhist and Taoist, 4.5% of Christian, and 2.5% accounted for other types of religion. While China still claims Taiwan as one of its provinces, Chinese Taipei's political system is a semi-presidential republic with the Chief of state being the President and the Head of government represented by the Premier.

Education in Chinese Taipei is provided, maintained, and overseen by the Ministry of Education of the Republic of China. According to Hardre et al. (2006), the education system consists of: six years in elementary school, three years of junior high school, and three years of senior secondary education. Beyond the secondary education, higher education is also governed by the Ministry of Education. The authors further presented that a series of ongoing educational reforms have been attempted in order to address the criticism of focusing on memorization as well as the lack of being creative from those students who graduated from Chinese Taipei's education system.

Hong Kong. Hong Kong is geographically located in the eastern Asian bordering the South China Sea and China with a total land area of 427 square miles and an approximate population of 7.3 million of various ethnics. According to Hong Kong SAR Census and Statistics Department (2016), the ethnic groups include 93% of Chinese, 1.9% of Indonesian, 1.9% of Filipino, and 3% of others. The official languages in Hong Kong are Cantonese (85%) and English (3.5%) along with other languages of Mandarin Chinese (3.5%), other Chinese dialects (4%), and others (1.6%). There exists an eclectic mixture of local religions (90%) and Christian (10%).

Schenk (2008) explained that China agreed and promised that Hong Kong would remain as the Special Administrative Region of the People's Republic of China in 1997. She stated that China's socialist economic system would not have any impact on Hong Kong. Hence, Hong Kong still remains as a free market economy that highly depends on international trade and finance. However, Hong Kong is politically governed by the People's Republic of China with the Chief of state being the President of China and the Head of government being the Chief Executive of China.

There are several agencies that contributed to the education system in this special region of China. The Education Bureau (EDB) is primary charged with formulating, developing, and reviewing any educational policies, programs, and legislation in all levels of schooling. Currently, Hong Kong's education system comprises of six years of primary school, three years of junior secondary school, and three years of senior secondary school. Beyond those 12 years are another four years of university study which is more common to system in the mainland China and the rest of the world (IEA, 2016).

Japan. Japan is located in the eastern Asia with a cluster of islands between the North Pacific Ocean and the Sea of Japan and east of the Korean Peninsula. Consisting more than thousands of islands, Japan's total land area is approximately 146 thousand square miles with four major islands comprise of at least 97% of the land. According to Japan's Statistics Bureau (2016), the current population in Japan is about 126 million with 98% of Japanese, 0.5% of Korean, 0.4% of Chinese, and 0.6% of other ethnic groups with Japanese being the official language. The religions in Japan are more diverse as compared to their ethnic groups. These religions include Shintoism (79.2%), Buddhism (66.8%), Christianity (1.5%), and others (7.1%). It is important to note that many Japanese practice both Shintoism and Buddhism; hence, the percentage adds up to more than 100%.

Japan's political system represents a parliamentary constitutional monarchy with the Chief of state being Emperor and the Head of government being the Prime Minister. According to Ministry of Foreign Affairs of Japan (2016), with its government-industry cooperation, Japan has developed an advanced economy. Japan has become one of many technologically advanced producers of motor vehicles, electronic equipment, machine tools, steel and processed foods. Similarly, to the United States education system, Japan is influenced with model of schooling as six years of elementary school, three years at lower secondary school, and three years of upper secondary school. Beyond secondary school is followed by another four years at the university level. The Ministry of Education is in charge to monitor, develop and issue any educational reforms as needed. Hence, Japanese school children consistently achieve impressive results in international assessments (Clark, 2005).

Malaysia. Malaysia is located in the Southeastern Asia. Its location's peninsula is bordering with Thailand and northern one-third of the island of Borneo is bordering with Indonesia and

Brunei. The country is also shared its part with the South China Sea and south of Vietnam. According to Department of Statistics Malaysia (2016), its current population is approximately 30.9 million consisting of Malay (50%), Chinese (22.6%), indigenous ethnic groups (11.8%), Indian (6.7%), other ethnic groups (0.7%), and non-citizens (8.2%). Since Malaysia is very diverse in the number of ethnic groups among its population, beside Bahasa Malaysia is the official language, there exist numerous different languages such as English, Chinese (Cantonese, Mandarin, Hokkien, Hakka, Hainan, Foochow), Tamil, Telugu, Malayalam, Panjabi, and Thai. On that same note, Malaysia also has different types of religion including the official Muslim (61.3%), Buddhist (19.8%), Christian (9.2%), Hindu (6.3%), Confucianism, Taoism, and other traditional Chinese religions (1.3%) (Malaysian Department of Statistics, 2016).

The political system in Malaysia is a federal constitutional monarchy with the Chief of state being the King who serves primarily as ceremonial position and the Head of government being the Prime Minister who is designated from among members of the House of Representatives. According to Ministry of Foreign Affairs of Malaysia (2016), Malaysia has become an emerging multi-sector economy in the past 70 years. It has maintained a middle-income country due to its prosperity in economic. The current Malaysian Prime Minister and his cabinet members are working toward a high-income status by 2020. Primary, secondary, and higher education are all under the accountability and responsibility of the Ministry of Education. Malaysian school year starts in January and ends in November. The primary education consists of six years while the secondary education lasts seven years with two stages: five years of junior secondary and two years of senior secondary.

Republic of Korea. Republic of Korea is often known as South Korea and is located in the Eastern Asian. Southern half of the Korean peninsula is bordering with the Sea of Japan and the Yellow Sea. Korean total land area is about 84.6 thousand square miles with a population estimated at 50.9 million. The country itself remains as a homogeneous ethnic group using Korean and English that are widely taught in secondary schools. According to Statistics Korea (2016), religions in Korea consist of Christian (31.6%), Buddhist (24.2%), and no religion (43.3%).

Korean political system is based on the presidential republic with the Chief of state being the President who is directly elected by simple majority of popular vote and the Head of government being the Prime Minister who is appointed by the President and approved by the National Assembly. The Republic of Korea has developed an incredible economy that demonstrates growth and global integration in high-tech industrialized economy. According to Statistics Korea (2016), in 2004, South Korea joined the trillion-dollar club among other countries to the world economies. The Ministry of Education, Science, and Technology (MEST) is responsible for overseeing the education system in South Korea. The Ministry set forth directions and standards for school inspections that evaluate teaching and learning practices. School for children between six and fifteen is free while senior high school students have to pay tuition fees to supplement the government funding. In other words, primary and middle schools (grads 1 -9) are compulsory and free in South Korea while high school that lasts in three years requires paid tuition and admission is based on middle school academic records.

Singapore. Singapore is located in the Southeastern Asian with islands between Malaysia and Indonesia. Singapore's total land area is about 278 square miles with a population estimated at 5.7 million. According to Department of Statistics Singapore (2016), the country consists of several ethnic groups including Chinese (74.2%), Malay (13.3%), Indian (9.2%), and others (3.3%). On the same note, its diverse languages being used in Singapore contain the official

Mandarin (36.3%), official English (29.8%), official Malay (11.9%), official Tamil (3.2%), Hokkien (8.1%), Cantonese (4.1%), Teochew (3.2%), other Indian languages (1.2%), other Chinese dialects (1.1%), and others (1.1%). The major religion in Singapore is Buddhist (33.9%) in combination with Muslim (14.3%), Taoist (11.3%), Catholic (7.1%), Hindu (5.2%), other Christian (11%), others (0.7%), and no religion (16.4%).

Singapore's political system is based on the parliamentary republic with the Chief of state being the President who is directly elected by a simple majority popular vote and the Head of government being the Prime Minister who is usually the leader of majority party and appointed by the President (Singapore Ministry of Foreign Affairs, 2016). The country has become one of many highly developed and successful free-market economies. Its unemployment is quite low since the economy depends on exports of consumer electronics, information technology products, and financial services. Unarguably, Singapore education system has been widely known for its success in developing the children' strengths and social skills. IEA (2016) stated that schooling in Singapore includes six years of primary school prior to moving into secondary school in which students are allowed to make a selection of normal secondary school, a specialized school, an expressed school, or another school that is privately funded. Beyond secondary school, students can spend one to three years in higher education including junior college, polytechnics, and institutes of technical education.

Thailand. Thailand is located in the Southeastern Asia and bordering with the Andaman Sea and the Gulf of Thailand. It is the only Southeast Asian country has never been colonized by the European power. Data analysis from Thailand National Statistical Office (2016) showed that Thailand consists of 198 thousand square miles in total land area along with a population estimated at 68.2 million. The major ethnic group in Thailand is Thai (95.9%) and the remainder includes Burmese (2%), other (1.3%), unspecified (0.9%). The official language is Thai with the note for those who consider themselves as an elite, English becomes the secondary language. Joining with other Asian countries in the region, Thailand's religions consist of Buddhist (93.6%), Muslim (4.9%), and Christian (1.2%), other (0.3%) (NSO, 2016).

Thailand's political system is based on the constitutional monarchy with the Chief of state being the King and the Head of government being the Prime Minister who is appointed by the monarch with a resolution of the National Legislative Assembly (Ministry of Foreign Affairs, 2016). Historically, Thailand has had a strong economy. However, due to its domestic political conflicts between the parties and government, the economic growth has been stalled. The country's education system is divided into 76 administrative provinces and guided by the National Education Act of 1999 and the 15-year National Education Plan. Students receive 12 years of free public schooling with the compulsory of the first nine years in primary and secondary education. Beyond those nine compulsory years, students can further complete three years of upper secondary education before joining the labor market or moving into higher education (IEA, 2016).

In summary, Table 3.2 depicts the educational system in seven APT countries. In general, the APT countries all have 6 years of primary education (Grade 1 to Grade 6). Out of the seven APT countries, Malaysia has only 11 years of primary and secondary education in combination and Singapore has 10 to 11 years of primary and secondary education; the other five APT countries all have 6-3-3 educational model. Each APT country has its own language of instruction; however, due to their diverse demographic and population, Malaysia and Singapore also use different language in teaching and learning.

Table 3.2

Education System from Seven APT Countries and Their Language of Instruction

Country	*Primary Education*	*Lower Secondary Education*	*Upper Secondary School*	*Languages of Instruction*
Chinese Taipei	6 years	3 years	3 years	Mandarin Chinese
Hong Kong	6 years	3 years	3 years	Chinese and English
Japan	6 years	3 years	3 years	Japanese
Malaysia	6 years	3 years	2 years	Bahasa Malaysia
Republic of Korea	6 years	3 years	3 years	Korean
Singapore	6 years	4 – 5 years		English
Thailand	6 years	3 years	3 years	Thai

Data Collection and Instruments

Instruments of eighth-grade mathematics assessment survey. TIMSS 2015 is the most recent in the TIMSS series that dated back to its first assessment in 1999 and has been subsequent thereafter every four years. Hence, TIMSS 2015 eight-grade mathematics assessment was a continuation of the long history in international assessments in mathematics and science. Gronmo et al. (2016) further presented that the TIMSS 2015 assessment frameworks were similar to those used in TIMSS 2011 although there were “minor updates to particular topics to better reflect the curricula, standards, and frameworks of the participating countries” (p. 2). By doing so, fresh ideas and current information about any changes in curricula, standards, frameworks, and instruction in mathematics and science are more relevant to the present-day. However, the curriculum framework designs used in the previous years were also utilized to ensure reliable measurement of trends in mathematics and science learning and teaching over the span of 20 years. In other words, the framework for the TIMSS 2015 mathematics assessment was similar to those used in TIMSS 2011 with some updates due to current international studies and initiatives including Common Core State Standards for Mathematics in the United States, the Mathematics Syllabi in Singapore, and the Mathematics Curriculum Guide in Hong Kong.

Test booklet. The complete TIMSS 2015 assessment contains a large set of mathematics and science questions for fourth- and eighth-grade, 350 items and 450 items, respectively. TIMSS 2015 used a matrix-sampling method to assign the entire assessment questions pool for mathematics and science into a set of 14 student achievement booklets, with each individual student completing only one booklet. As in TIMSS 2011, TIMSS 2015 had a total of 28 blocks (14 for mathematics and 14 for science) with 12-18 items in each block at the eighth-grade level. TIMSS 2015 also contained 16 blocks of trend items (8 mathematics and 8 science) and 12 blocks (6 for mathematics and 6 for science) of questions newly developed to replace those questions were retired and released to the public after the 2011 administration.

Item blocks were used in all TIMSS administrations in order to collectively gather information for each participating country. Since each student only responded to a set of questions in each block of the test booklets, students mutually responded to the content and cognitive questions in TIMSS assessment. In addition, each block of the assessment would have one new set of mathematics questions and one trend set of questions from the previous administration.

The major goal for TIMSS 2015 was similar to those in the previous years. In an essence, the task is to effectively and efficiently distributing the assessment items so that students responded sufficiently enough to record reliable data information of trends both in mathematics and science. Hence, it is important to have a linkage among test booklets while keeping a minimum number of test booklets by presenting each block in two booklets. In other words, the distribution of test booklets as designed in order to still obtain the goal of assessing trends in mathematics and science.

In summary, each student completed one student achievement booklet containing two parts and a set of questionnaire. Each achievement test booklet consists of one block of items from the previous TIMSS and one set of new items with the exception of booklet numbers 5 and 6 since both parts of the mathematics and science items are from TIMSS 2011. At the eighth-grade level, students were allowed to spend 45 minutes in each part of the booklet and extra 30 minutes at the end of the administration for the student questionnaire.

Procedures of Data Collection and Analysis

To understand how student and teacher/classroom variables influence student mathematics achievement, I utilized the student-related background variables which categorized into two sets (student-related background and student home resources) collected from TIMSS 2015 including: student gender, self-confidence in learning mathematics, valuing of mathematics, liking mathematics, enjoying mathematics, time spent on homework, time spent in tutorial, computer access, parental highest educational background, and having their own room to study at home. Furthermore, classroom-related background variables include teacher gender, teacher years of experience, and major of study, job satisfaction, class size while school-related variable will be the total number of available computers. The following sections will address the design and method, data sources, data collection, secondary data analysis and the assumptions of HLM.

Design and method. Understanding of how classrooms and teachers affected students' outcomes has been debated for several decades. At the same time, advances in the field of technological and educational research have positioned multilevel modeling technique as one of the most powerful analysis tools in examining the effects of different hierarchical variables. In that vein, O'Dwyer (2002) believed that the potentiality of multilevel modeling application allowed policy decisions being made by understanding "how formal education is affected by schools, classrooms, teachers, and changes that occur over time" (p. 359). In that vein, Grilli et al. (2015)

reiterated that the multilevel modeling approach allows researchers to fully comprehend "the residual correlation between pairs of outcomes at both hierarchical levels" (p. 2). The authors believed that using this approach will create a full picture of student performance and the impact of background variables to student outcomes. Grilli et al. once again confirmed Yang et al. (2002) methodological perspectives which indicate the multivariate models "is a well-established tool" (p. 2) because it accounts for "correlated responses at levels where dependencies of observations occur" (Ma, Ma & Bradley, 2008). Furthermore, the sampling design in TIMSS which employed a two-stage stratified procedure (Mullis, 2000) limited the number of levels that can be modeled. Snijders and Berkhof (2007) believed that if the researchers ignore this sampling design in analyzing the data, the interpretations of the findings may be inaccurate.

Data sources. This study utilizes the data from Trends in International Mathematics and Science Study (TIMSS) that was conducted by the International Association for the Evaluation of Educational Achievement (IEA) and maintained by the National Center for Education Statistics (NCSE). TIMSS 2015 comprised of student achievement scores in mathematics and science as well as student, teacher/classroom, school, and other background statistics for more than 580,000 participated students in fourth and eighth-grade from 57 countries and seven benchmarking entities (IEA, 2016). More specially, the eighth-grade mathematics achievement score, student demographic background, mathematics teacher background, and school information will be utilized and analyzed for the purpose of this research.

The globalization and the impact of how countries economically compete with each other around the world, there exists the need for an examination of trends and issues on international education among the countries in order to understand such effects. Originally, TIMSS was piloted in 1995 with a mission to measure student achievement in mathematics and to provide regular and timely data for classroom teachers and policy makers on student mathematics achievement trends (Martin, Mullis, & Foy, 2016). TIMSS assessments continue on for every four years, in 1999, 2003, 2007, 2011, and most recently in 2015 that marked the trends in 20 years. According to IEA's mission and goals, TIMSS was intentionally used to evaluate and monitor trends on students' mathematics and science achievement with the ultimate goal of helping "countries make informed decisions about how to improve teaching and learning in mathematics and science" (IEA, 2016, para. 8). TIMSS 2015 database is the largest and most recent international student achievement scores in mathematics and science with more than 57 countries and seven benchmarking entities participated. Furthermore, TIMSS database contained numerous student, teacher/classroom, and school factors that could be exploited to examine the association between contextual and background structures and student mathematics achievement for within and between countries.

Data collection. Johansone (2016) explained the operations of data collection for TIMSS 2015 as being scheduled in accordance with 60 participating countries located in the southern and northern hemispheres. School year typically ends in November or December for those schools in the southern hemisphere, the TIMSS assessment was given out in October or November 2014. Whereas school year usually ends in May or June for those schools in the northern hemisphere, the assessment was conducted in April, May, or June 2015. Survey and assessment operations procedures were developed and standardized to ensure the consistency and uniformity of high-quality internationally comparable data among the participating countries. Each country or benchmark entity was charged to carry out the data collection process as well as to maintain quality control procedures in accordance with the guidelines set forth from the National Research

Coordinators. Testing administrators and participating school personnel were provided training in test security, timing, rules for answering students' questions, and control monitors in order to maintain the high quality and accurate data for TIMSS 2015 survey and assessment.

Managing the data. Because of the complexity of an international database, it was necessary to further manage and screen the data after selecting the seven Asian countries by utilizing the *IEA IDB Analyzer* (see Sandoval-Hernandez, 2014) in conjunction with *SPSS* software. The screening, merging, and managing process is illustrated in Figure 3.1 below. Because each country has its own database, importing the selected countries' data into one SPSS file for managing and analyzing is essential. At the same time, each country has its own student achievement, student background, teacher link file, teacher background, and school background, the important task was to link and merge those separate files together in order to attain one workable and analyzable *SPSS* file. Student ID was used to merge student achievement, student background, and teacher link files together. This merged file was later merged with teacher background using teacher ID. Once the merging was completed, only needed variables were kept for further analyses. Moreover, as part of the analyses, variables were recoded so that they were in line with the research purpose and questions.

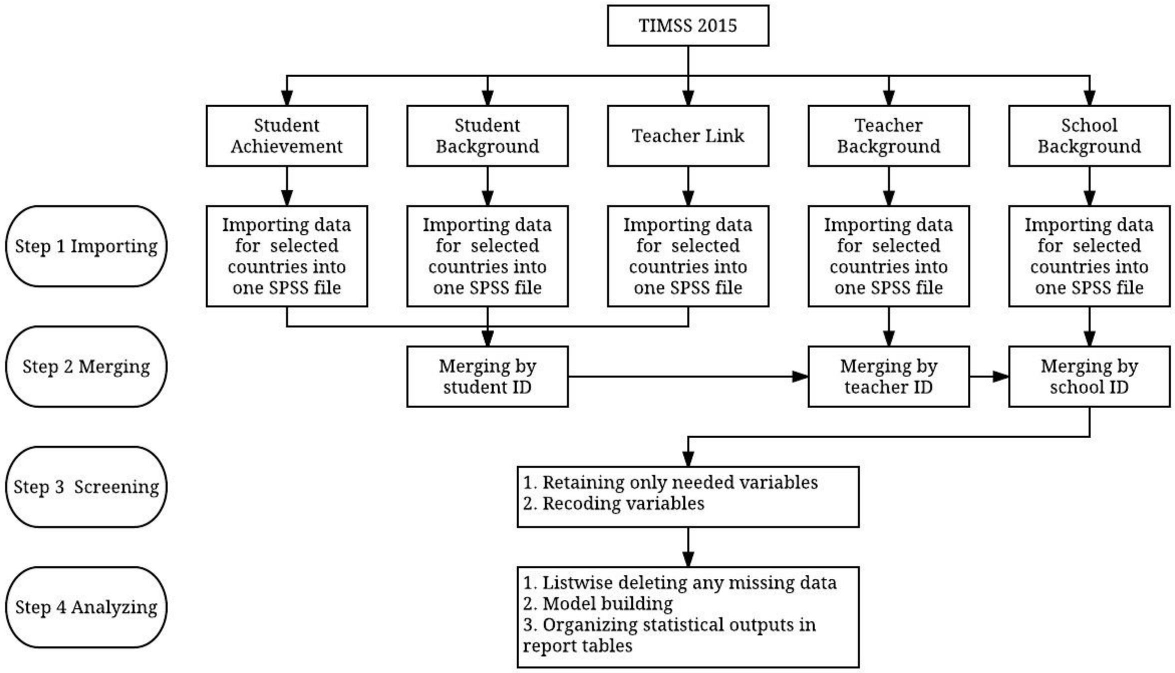

Figure 3.1. Researcher's flowchart for importing, merging, retaining, recoding, and analyzing TIMSS 2015.

Since TIMSS 2015 database is a huge combination of various variables and information from the participating countries, missing data is more likely to occur and needed to be addressed prior to the HLM analyses. Each selected country will undergo the inspection of missing data at both student level and classroom level. Listwise deletion was utilized to remove all missing data at both of those two levels because the parameter estimated in HLM analyses are computed based on the complete cases. As compared to other methods of eliminating the missing values, listwise deletion was chosen for this research because of its simplicity and commonness in handling missing data. Roth (1994) and Allison (2001) suggested that listwise deletion was more likely to produce the least biased estimates in analyses because of its simplicity and comparability across analyses. It is worth to note that listwise deletion may produce unbiased regression slope estimates as long as the missing values are not a function of the outcome variable. Also, Phan and Kromrey (2006) reiterated that statistical results produced by the listwise deletion were similar to those produced by the multiple imputations method for large-scale assessment database.

Data Analysis – Secondary Data Analysis

Hierarchical linear model. Rosenberg et al., (2006) indicated that utilizing the secondary data in the recent years has become more common in the field of social science. However, the use of such database must be carefully evaluated for their advantages and disadvantages as well as which appropriate method of analysis could be utilized for such data set in research. Often time, educational databases are often nested naturally within the structure. For instance, houses are nested within neighbors, neighbors are nested within cities, cities are nested with counties, and counties are nested within states. Also, students are nested within teachers, teachers are nested within schools, and schools are nested within districts. In order to analyze these data sets, traditional methods of linear modeling are not appropriate because of the violations of the independence assumption for such method (Osborne, 2000).

With the traditional statistical methods such as ordinary least squares (OLS), the analysis of data at the aggregate level becomes cumbersome. In other words, data were collected from individuals (level 1) and then being aggregated to advance insights into the clusters (level 2) in which those individual belong to. As Nezlek and Zyzniewski (1998) presented that the flaw of these traditional methods of analysis was due to the inferences about the groups being drawn from the individual-level factors. At the same time, information could have been collected at the group level and then disaggregated into the individual level. By ignoring this group information when disaggregating the data, the assumption of independent observation would be violated; hence, the standard errors would be misestimated (smaller than they should be).

In an essence, utilizing the multilevel models with respect to student-, classroom-, and school-related variables will address the issue of statistical properties of the data. In the ordinary least square (OLS) modeling, the assumption of single level approach is that the observations are independent of each other. On the other hand, the assumption of independence becomes invalid in hierarchical structured models since data collected from individuals who belong to the same group lean towards having similar characteristics; hence, error terms are more likely to be correlated (Raudenbush & Bryk, 2002, 2004). When such OLS is used to examine nested data with correlated errors, the standard errors will be smaller than they should be. This, in turn, will create a greater chance of committing Type I errors. Alternately, hierarchical linear models (HLM) account for both within and between group variability at two or more levels; therefore, they produce the appropriate and unbiased errors. At the same time, HLM allow estimation of cross-level effects that is not conceptual defined in the OLS models (Huta, 2014).

Furthermore, the multilevel models and techniques that were first published by Raudenbush and Bryk (1986) addressed the issue of nestedness within the data. Predictor variables are conceptually distinct at different levels. Hence, the data in the multilevel approaches can be analyzed in terms of the levels as well as in relation to the nested levels such as within and between groups. They noted that at the lower level, the characteristics or processes could be influenced by the characteristics or processes at the higher level of analysis.

Each country's descrtiptive statistics including frequencies and means were calculated for both criterion and predictor variables by student and classroom level using *SPSS v*24. Figures and tables would be used to represent the univariate analysis of distributions of the criterion and predictor variables in this study. At the same time, the bivariate relationships between student and classroom level predictor vaiables would be inspected for each country using *SPSS v*24.

Because of the sampling method and design, classrooms were selected within each school to make up the sample, preliminary TIMSS data presented that about one classroom per school was recorded and participated in the administration. For that reason, this study focused on analying the student level and classroom level.

Raudenbush and Bryk (2002) presented the advantages of using a multi-level multiple regression in analyzing nested data. Hence, the hierarchical linear modeling (HLM) was employed to analyze the TIMSS database since the data reports by students nested in teachers/classes. For the purpose of this study and the TIMSS sampling design, two level models of HLM would be constructed at the student and classroom levels. At the student level (level-1), student background and student home resources variables are unique across students while teacher/classroom level (level-2), the predictor variables are represented by teacher backgound characterisitics in combination with classroom characteristics.

Model building. HLM analyses for this study were conducted by utilizing *HLM v*7, a computer based software developed for analysis of hierarchical structured data by Raudenbush, Bryk, Cheong, and Congdon (2004). The HLM analyses will start off with the *null* model (unconditional) acting as a baseline or unconditional model which has no student or classroom variables. This is the simplest two-level models that had no predictor variables across the two levels. This step presented disparity of the student achievement across the two levels without taking into account of any predictor variables. Raudenbush and Bryk (2002) reiterated that the base models would allow which predictor variables are needed when building the conditional models. The regression equation of this unconditional model is shown below:

Level 1: $$Y_{ij} = \beta_{0j} + r_{ij} \quad (1)$$

Level 2: $$\beta_{0j} = \gamma_{00} + u_{0j} \quad (2)$$

In this model, Y_{ij} is student mathematics score of student i in classroom j,

β_{0j} is regression intercept of classroom j,

γ_{00} is the overall average mathematics score in classroom j,

u_{0j} is the random effect of classroom j,

r_{ij} is the random effect of student i in classroom j.

According to Raudenbush and Bryk (2002), the unconditional two-level model separated the variability of the outcome Y_{ij} into two parts: student in a classroom σ^2(level 1), and classroom within a school τ_{00} (level 2). Within this unconditional model, the variance calculated could be explained by measured variables at each level. Both authors suggested that several conditional models could be tested with different predictor variables to identify factors that influence the student achievement score.

To investigate the research questions, I utilized the regression-based technique of hierarchical linear modeling. Raudenbush and Bryk (2002) suggest hierarchical linear modeling (HLM) has advantages over ordinary least squares regression in that it separates the variance into within-cluster and between-cluster components and calculates the explanatory power of the predictor variables at both levels simultaneously. The research questions were hierarchical in that I was interested in both student-level characteristics and classroom-level characteristics that were related to student mathematics achievement. Using restricted maximum likelihood estimation, HLM 7 software (Raudenbush, Bryk, & Congdon, 2010) allowed me to represent a collection of regression coefficients as multivariate outcomes to be simultaneously explained as a function of measured differences between classrooms.

The hierarchical linear model was built using a multistep approach. This approach allowed me to consider all the relevant variables while keeping the model at its simplest. First, I fit a fully unconditional two-level model which consisted of only the dependent variable—student mathematics achievement— to estimate the variance components at each level. This is equivalent to what one would find using an unbalanced one-way random-effects ANOVA, where institution is a random factor with varying numbers of students per classroom. Second, level-one predictors were included in the model. To be consistent in comparisons between the seven countries, all level-1 variables were left in the model. All level-1 variables were centered around their grand means. The decision of grand means really was based on several authors' recommendations in terms of grand mean centering when examining the effects of level-2 controlling for level-1 variables and for ease of interpretation of intercept and slope parameters in HLM (Enders & Tofighi, 2007; Algina & Swaminathan, 2011).

Third, each level-1 predictor random effect was tested for its significance in the intercept and coefficients using the likelihood ratio test. Then, level-2 variables were added in the model for the estimated intercept. The equation of the conditional model is listed as following at level one:

$$MATHACH_{ij} = \beta_{0j} + \beta_{1j}(STUGEN_{ij}) + \beta_{2j}(STUCON_{ij}) + \beta_{3j}(STUVAL_{ij}) + \beta_{4j}(STULIK_{ij}) + \beta_{5j}(STUENJ_{ij}) + \beta_{6j}(STUHMW_{ij}) + \beta_{7j}(STUTUR_{ij}) + \beta_{8j}(STUCOM_{ij}) + \beta_{9j}(STUPAR_{ij}) + \beta_{10j}(STUROM_{ij}) + r_{ij} \tag{4}$$

where

$MATHACH_{ij}$ was the achievement score of student *i* in classroom *j*;

β_{0j} regression intercept of classroom *j ;*

β_{pj} corresponding student-level coefficient in classroom *j;*

r_{ij} random effect of student *i* in classroom *j*.

The conditional level-2 model is a function of classroom effect on student achievement as following:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(TEAGEN_{ij}) + \gamma_{02}(TEAEXP_{ij}) + \gamma_{03}(TEAMAJ_{ij}) + \gamma_{04}(TEASAT_{ij}) + \gamma_{05}(TEACLS_{ij}) + u_{0j} \quad (5)$$

where

γ_{00} overall average mathematics score in classroom j;

γ_{0q} corresponding classroom-level coefficient; and

u_{0j} random effect of classroom intercept j.

Assumptions of HLM. Raudenbush and Bryk (2002) proposed six assumptions when working with HLM to ensure the validity of the analyses. These assumptions must be carefully examined to avoid bias in resulted estimates as they pertain to the adequacy of model specification and the consistency of the parameter estimates.

1. Student related variables (level-1) residuals (r_{ij}) is independent and normally distributed with a mean of 0 and variance σ^2 for every level-1 unit i within each classroom (level-2) j.
2. Student related variables are independent of the level-1 residuals (r_{ij}).
3. Classroom related variables (level 2) residuals (u_{0j} and u_{1j}) are multivariate normal, each with a mean of 0, variance and covariate. The level-2 residuals are independent among the classroom clusters.
4. The set of classroom related variables are independent of every level-2 residual (u_{0j} and u_{1j}).
5. The residuals at student (r_{ij}) and classroom level (u_{0j} and u_{1j}) are independent.

6. The student related variables are not correlated with the classroom residuals (u_{0j} and u_{1j}), and the classroom related variables are not correlated with the student residuals (r_{ij}).

Of these six assumptions, assumptions 2, 4, and 6 concentrate on the relationship among the predictor variables (level-1 and level-2) within the structure of the model. In other words, these assumptions deal with the adequacy of model specification so that bias will not occur in *gamma* estimates (level-1 and level-2 fixed effects). The other three assumptions 1, 3, and 5 pertain to random part of the model. Raudenbush and Bryk (2002) presented that violations to these assumptions will affect the consistency and accuracy of the estimates of the standard errors of level-2 fixed effects, the level-1 random effects, the variances for level-1 and level-2, and the confident intervals of the hypothesis tests. For that purpose, the assumptions were checked to determine if there were any violations prior to analyzing the database.

Reliability and Validity

According to Foy et al. (2015), addressing and validating the reliability of the TIMSS 2015 assessment was a critical quality control step in examining the items. At the assessment booklet level, a review of Cronbach's Alpha coefficient of reliability was calculated and considered. Furthermore, the constructed response items had to reach certain reliability requirements in terms of being consistent within-nation scoring, cross-nation scoring, and across assessment or trend-scoring (Foy et al., 2015). In short, TIMSS 2015 was administered to different participating countries and nations; therefore, in order to obtain reliable scores and results, reliability extends to the consistency of how instrument was used, the environment was utilized, the students responded, and how the instrument was scored. The design and construction of TIMSS assessment framework allows that every student responded to enough items to provide reliable measurement of trends in mathematics (Martin, Mullis, & Foy, 2015). Also, multiple-choice items provide students with four response options, of which only one is correct, allow valid, reliable, and economical measurement in such a short time period. In all, reliability and validity issues in this study followed with terms and conditions set forth in TIMSS frameworks and reports.

Also, because the study examined the influence of several predictor variables on student achievement outcome, the issue of multi-collinearity may arise and would alter the estimates and the interpretations of the findings. Therefore, a preliminary step was taken into accounts before the predictor variables were used to build the two-level models. Once the data had been merged, *SPSS* was utilized to check for multi-collinearity by examining the correlation matrix between the predictor variables.

Variables and Definitions of Terms

There were three sets of independent variables and one dependent variable. The sets of independent variables included: (1) student background, (2) student home resources, and (3) teacher and classroom background. The student background category was measured by seven background variables: student gender, self-confidence in learning mathematics, valuing of mathematics, liking mathematics, enjoying mathematics, time spent on homework, and time spent in tutorial. Home resources were measured by whether or not students had access to a computer, parental educational background, and having their own room to study at home. Teacher background was measured by teacher gender, the years of experience, the major of study, and teacher job satisfaction while classroom background was represented by class size (the number of students in classroom) and the number of available computer at the school level. Because of the TIMSS sampling method and design, the number of schools (level-3) would be equated to the number of classrooms (level-2). All definitions of terms are adopted from TIMSS

2015 User Guide (Foy, 2015). Dummy coding was utilized for the categorical variables and listed within each variable's description.

Mathematics achivement (MATHACH), which is the dependent variable, is the overall mathematics academic performance score that summarizes student performance on test items designed to measure understanding of content in algebra, number, geometry, measurement, and data and a range of processes in the cognitive domain including knowing, applying, and reasoning. Based on TIMSS sampling method and design, each student took only a subset of the mathematics assessment and the plausible scores would be imputed to produce the overall student achievement (Wang, 2001). For this study, the overall student achievement was used to determine the variance within and between classrooms.

Student confidence in learning mathematics (STUCON) is based on the students' reports on the extent of their agreement in terms of how well they do in mathematics, how hard mathematics is, how quickly they learn mathematics, how good they are at solving difficult mathematics problems, how good they are at mathematics per teacher's comments, and how hard mathematics is compared to other subjects. According to TIMSS 2015 user guide, students who were *Confident* with mathematics had an average score of at least 12.1 corresponding to their "agreeing a lot" with five of the nine stsatements and "agreeing a little" with the other four. Students who were *Not Confident* with mathematics had an average score of no higher than 9.5 corresponding to their "diagreeing a little" with five of the nine statements and "agreeing a little" with the other four. All other students were *Somewhat Confident* with mathematics. Student confidence level was reported as the degree of agreement and then "student confident in mathematics scale was created based on student's degree of argreement with the nine statements described" (TIMSS 2015, p. 1).

Valuing of learning mathematics (STUVAL) is based on students' reports in terms of how useful mathematics is in daily life, how necessary mathematics is in order to learn other subjects, get into the university of their choice, and get the job they want, how involved mathematics is with their job, and how important it is to do well in mathematics. According to TIMSS 2015 user guide, students who *Value* mathematics had an average score of at least 10.3 corresponding to their "agreeing a lot" with five of the nine stsatements and "agreeing a little" with the other four. Students who *Do Not Value* mathematics had an average score of no higher than 7.7 corresponding to their "diagreeing a little" with five of the nine statements and "agreeing a little" with the other four. All other students *Somewhat Value* mathematics. Students value mathematics was reported as the degree of the agreement level and then the scale score was created based on the degree of agreement with the statements (TIMSS, 2015).

Liking in learning mathematics (STULIK) is based on the students' reports in terms of enjoying learning mathematics, wishing no studying of mathematics, seeing mathematics a boring subject, learning many interesting things in mathematics, and liking the subject. According to TIMSS 2015 user guide, students who *Like Learning Mathematics* had the responses averaged with at least 11.4 corresponding to their "agreeing a lot" with five of the nine statements and "agreeing a little" with the other four statements. Students who *Do Not Like Learning Mathematics* had an average score with no more than 9.4 corresponding to "disagreeing a little" with five to the nine statements and "agreeing a little" to the other four statements. All other students *Somewhat Like Learning Mathematics*. Students like mathematics was reported as the degree of the agreement level and then the scale score was created based on the degree of agreement with the statements (TIMSS, 2015).

Enjoying learning mathematics (STUENJ) is based on the students' reports in terms of how they enjoy learning mathematics through a set of nine questions. According to TIMSS 2015 user guide, students who *Enjoy Learning Mathematics* had the responses averaged with at least 12.4 corresponding to their "agreeing a lot" with five of the nine statements and "agreeing a little" with the other four statements. Students who *Do Not Enjoy Learning Mathematics* had an average score with no more than 8.4 corresponding to "disagreeing a little" with five to the nine statements and "agreeing a little" to the other four statements. All other students *Somewhat Enjoy Learning Mathematics*. Students enjoy mathematics was reported as the degree of the agreement level and then the scale score was created based on the degree of agreement with the statements (TIMSS, 2015).

Time spent on homework (STUHMW) is derived from students' reports of how often the teachers assigned homework and how many minutes they spent on mathematics homework. Students' responses to the frequency of homework assigned were coded on a 5-point scale while responses to how much time they spent were coded on a 6-point scale. For this study, the time spent on homework was dummy coded into a dichotomous variable which comprised of spending 60 minutes or less and more than 60 minutes on homework. The decision of collapsing the categories was based on the current literature review and for ease of interpretation. As cited in NEA (2017), Harris Cooper suggested that "10-20 minutes per night in the first grade, and an additional 10 minutes per grade level thereafter" (para. 4). Hence, for that purpose, 60 minutes was selected as the middle point to recode the variable in this study.

Time spent in tutorial (STUTUR) is also derived from students' reports of how often students came to tutorial and how many minutes they spent in tutorial. Students' responses to the frequency of coming to tutorial were coded on a 5-point scale while responses to how much time they spent were coded on a 6-point scale. In this study, the time spent in tutorial was also dummy coded into a dichotomous variable which comprised of spending less than 45 minutes and more than 45 minutes in tutorial. The decision of collapsing the categories was based on the current literature review and ease of interpretation. Kidron and Lindsay (2014) suggested that an optimal time for any tutorial is between 45 and 60 minutes. Hence, the cut-off was leveled at 45 minutes. The cut-off of 60 minutes would skew the representation of time spent in tutorial.

Computer access (STUCOM) is based on the students' responses in terms of educational aids in the home. The variable was coded as "yes" if all three responses to the possession of a computer, desk, and dictionary are yes, and "no" if any of the three responses are no. For the purpose of this study, the interest of having access to computer or not at home would aid in student learning which in turn improved student achievement was considered. Whether they had a computer or not, their "yes" response would be considered as having home resources to aid in learning.

Parental highest educational background (STUPAR) is derived from students' responses in terms of the highest level of education completed by the parents. The variable was reported as a categorical data, but for the purpose of this study, the predictor was dummy coded into a dichotomous variable which comprised of those who had postsecondary and above and those who had secondary education and below.

Having their own room to study (STUROM) is recorded from responding to two questions assessing the availability of an internet connection and/or student's own room. The responses were then categorized as "yes" or "no". The predictor was then dummy coded for ease of interpretation.

Years of experience (TEAEXP) is based on the teachers' reports in terms of the number of years in teaching. According to TIMSS 2015 user guide, the responses were categorized into less than 5 years, at least 5 but less than 10 years, at least 10 but less than 20 years, and 20 years or more. However, the responses were also recorded as a continuous variable; hence, the study utilized the continuous variable for the analysis and interpretation.

Major of study (TEAMAJ) is based on the teachers' reports in terms of the major prior to their teaching. TIMSS 2015 categorized and reported the responses as major in mathematics and mathematics education, major in mathematics but no major in mathematics education, major in mathematics education but no major in mathematics, and all other majors. For this research, the predictor was dummy coded into a dichotomous variable which comprised of mathematics major and no mathematics major.

Job satisfaction (TEASAT) is based on teachers' reports in terms of how content they are with teaching profession, how satisfied they are at the teaching school, how enthusiastic they are now compared to the start of the career, how important they are being a teacher, how long they stay in the profession, and how frustrated as a teacher. According to TIMSS 2015 user guide, students were scored according to their teachers' degree of agreement. Students with *Very Satisfied* teachers had an average score of at least 10.3 corresponding to their teachers "very often" with four of the seven statements and "often" with the other three. Students with *Less Than Satisfied* teachers has an average score no higher than 7.0 corresponding to their teachers "sometimes" with four of the seven statements and "often" with the other three. All other students had *Satisfied* teachers.

Class size (TEACLS) was reported by classroom teacher on the day the assessment was administered.

Total number of computers (SCHCOM) was derived from two questions assessing the availability of computers for instruction as reports by principals. The principals were asked to report the number of enrolled students as of the first day of the month TIMSS testing begins and the total numbers of computers that can be used for instructional purposes. The responses were recorded as a continuous variable that represented the number of available computer at the school.

ASEAN Plus Three Countries or ASEAN+3 (APT) was identified and used interchangeably throughout the study represent the seven countries being examined. Institutionalized in 1997, ASEAN leaders "agreed to strengthen partnership with the People's Republic of China, the Republic of Korea, and Japan to address mutual issues and concerns" (ARIC, 2017, para. 2) among the Southeast Asian Nations. APT has been a joint effort among ASEAN countries and its three cooperative members.

Chapter Summary

The examination of how student, teacher/classroom, and school related variables influence on student mathematics achievement in APT countries may or may not contribute a significant to the field of educational research and international educational evaluation. Although each country's data was examined to determine the impact of predictor variables on the achievement score, APT countries' analyses and findings, as a whole, would provide a strong evidence to support other future researches that focus more on different regions around the globe. Most importantly, the findings from this research hopefully provide research based educational reform to enhance teaching and learning mathematics.

In summary, I utilized the student-related background variables collected from TIMSS 2015 including: student gender, self-confidence in learning mathematics, valuing of mathematics, liking mathematics, enjoying mathematics, time spent on homework, time spent in tutorial, computer access, parental highest educational background, and having their own room to study at home. These student-level variables (level 1) later were categorized into two measures: student-related background and student home recourses. Furthermore, classroom-related background variables (level 2) included teacher gender, teacher years of experience, major of study, job satisfaction, class size, and the total number of available computers. Table 3.3 depicts the predictor variables and the outcome variable for this study.

Table 3.3
Summary of Predictor and Outcome Variables from TIMSS 2015

Variable		Description	Continuous	Categorical
Outcome				
	MATHACH	Mathematics achievement	x	
Level-1				
	STUGEN	Student gender		x
	STUCON	Confidence in math	x	
	STUVAL	Valuing math	x	
	STULIK	Liking math	x	
	STUENJ	Enjoying math	x	
	STUHOM	Time on homework		x
	STUTUR	Time in tutorial		x
	STUPAR	Parental education		x
	STUCOM	Computer access		x
	STUROM	Own room		x
Level-2				
	TEAGEN	Teacher gender		x
	TEAMAJ	Major of study		x
	TEAEXP	Years of experience	x	
	TEASAT	Job satisfaction	x	
	TEACLS	Class size	x	
	TEACOM	Number of computers	x	

4 RESULTS

Results for Chinese Taipei

Table 4.1 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) continuous variables, conducted by using *SPSS* 24. Of the complete sample of 5734 eighth-grade students nested in 183 classrooms, on average, the overall mathematics achievement for Chinese Taipei students was 601.33 (*SD* = 94.34) with the range of 555.19 points. Furthermore, eighth-grade students in Taiwan were on the upper half of having self-confidence in learning mathematics, valuing of mathematics, enjoying and liking in learning mathematics with the means of 9.11, 8.16, 9.18, and 9.24, respectively. At level-2, teacher years of experience showed a mean of 13.28 (*SD* = 7.65) ranging from one year to 39 years in the field. Teacher job satisfaction was in the upper half with a mean of 9.80 (*SD* = 1.98). Chinese Taipei classrooms, on average, presented a crowded learning environment with a mean of 31.79 (*SD* = 7.78). The average of number of available computers among the Chinese Taipei schools was 64.96 (*SD* = 48.44).

Table 4.2 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) categorical variables, conducted by using *SPSS* 24. At level-1, 51.10% of the participants was male and 48.90% was female. In terms of how much time Chinese Taipei students spent on homework, 64.20% of students responded that they spent less than 60 minutes while 35.80% spent more than 60 minutes. As for how much time they spent in tutorial, 40.10% said they spent less than 45 minutes while 59.60% answered that they spent more than 45 minutes after school. Computer access at home in Chinese Taipei divided into 55.10% owning of computer at home while 44.70% did not. More than half of the eighth-grade students responded that they had their own room to study at home. Parental education in Taiwan presented 43.30% of the parents had a post-secondary education and above while 47.30% had below secondary education. A listwise deletion of missing cases was utilized in the analysis and resulted with 4352 students at the level-1 and 183 classrooms at the level-2.

Table 4.1
Descriptive Statistics for Continuous Variables for Chinese Taipei

Variable	*N*	*Min*	*Max*	*Mean*	*SD*
Level 1					
Math achievement	5734	276.42	831.61	601.33	94.34
Valuing math	5726	3.00	13.65	8.16	1.74
Confidence in math	5725	3.20	15.93	9.11	2.39
Liking math	5722	4.97	13.98	9.24	1.85
Enjoying math	5722	3.77	13.62	9.18	1.91
Level 2					
Years of experience	183	1	39	13.28	7.65
Job satisfaction	183	4.73	12.79	9.80	1.98
Class size	183	1	55	31.79	7.78
Number of computers	183	0	310	64.96	48.44

Table 4.2
Descriptive Statistics for Categorical Variables for Chinese Taipei

Variable	*N*	*Percentage*
Student gender		
Male (0)	2926	51.10
Female (1)	2803	48.90
Missing	5	.10
Teacher gender		
Male (0)	3138	54.70
Female (1)	2567	44.8
Missing	29	.50
Time on homework (minutes)		
60 or less (1)	3566	64.20
61 or more (0)	1955	35.80
Missing	173	3.00
Time in tutorial (minutes)		
45 or less (1)	2297	40.10
46 or more (0)	3418	59.60
Missing	13	.30
Computer access		
Yes (1)	3158	55.1
No (0)	2652	44.7
Missing	14	.20
Own room		
Yes (1)	3620	63.10
No (0)	2103	36.70
Missing	11	.20
Parental education		
Post-secondary (0)	2483	43.30
Secondary and below (1)	2716	47.30
Missing	535	9.40
Major of study		
Mathematics (0)	2803	48.90
Non-mathematics (1)	2931	51.10

Bivariate relationships between variables were examined at each level. Table 4.3 presents the correlations among student (level-1) variables. It appeared from these analysis that level-1 predictor variables were uncorrelated from each other except how students valued learning mathematics and students liked learning mathematics with their self-confidence in learning mathematics, r = .48 and r = .74, respectively. Moreover, student valuing in learning mathematics was moderately correlated (r = .61) with how students liked learning mathematics. At the teacher and classroom (level-2), a bivariate relationship was also examined for five predictor variables.

Table 4.3
Bivariate Relationships between Level-1 Variables for Chinese Taipei

Variable	1	2	3	4	5	6	7	8	9	10
1. Student gender	1.00									
2. Confidence in math	-.01	1.00								
3. Valuing math	.00	.48	1.00							
4. Liking math	.00	.74	.61	1.00						
5. Enjoying math	-.03	.24	.33	.33	1.00					
6. Time on homework	.00	-.20	-.04	-.10	.04	1.00				
7. Time in tutorial	.02	-.02	-.02	-.02	-.03	.00	1.00			
8. Computer access	.01	-.01	-.05	-.03	-.01	-.03	.00	1.00		
9. Parental education	.05	.01	.03	.03	.01	.01	.01	.01	1.00	
10. Own room	-.01	.02	-.01	.00	.04	.01	-.03	.15	-.01	1.00

Table 4.4 presents the correlation matrix for these variables. None of the level-2 variables was correlated to each other. To ensure tenability of results yielded by hierarchical linear modeling in this research, the assumptions of both level-1 and level-2 were verified congruently model buildings with the predictor variables. The descriptive statistics of both level variables presented an approximate normal distribution in combinations with their skewness and kurtosis values. The analysis also suggested that there was evidence of homogeneity of level-1 variance. The assumptions of normality and homogeneity of level-1 and level-2 random effects were satisfied.

Table 4.4
Bivariate Relationships between Level-2 Predictor Variables for Chinese Taipei

Variable	1	2	3	4	5	6
1. Teacher gender	1.00					
2. Years of experience	.04	1.00				
3. Major of study	-.06	-.04	1.00			
4. Job satisfaction	-.04	.05	.04	1.00		
5. Class size	.07	-.02	.02	.13	1.00	
6. Number of computers	.05	.05	-.13	-.02	.25	1.00

The unconditional model, in which none of the level-1 or level-2 predictor variables was included, was first built using Hierarchical Linear Modeling software *version* 7 (HLM *v*7). The fixed effect estimate of the intercept was 604.04 (*SE* = 3.36, $p < .001$). The average of mathematics achievement was significantly different across the classrooms in Taiwan (τ_{00}= 1,802.22, *SD* = 42.45, $p < .001$). Within classrooms, the amount of unexplained variance was smaller than the between classrooms (σ^2= 6,177.88, *SD* = 78.60). The intra-class correlation (*ICC*) was then calculated using the formula,

$$ICC = \frac{\tau_{00}}{(\tau_{00} + \sigma^2)} = .23$$

The computed *ICC* of .23 represents the ratio of between-class variance and the total variance (within- and between-class variance) and indicated that 23% of the variance student mathematics achievement was between classes. That is, approximately 77% of the variance in student mathematics was attributed to student-level differences.

To answer the research questions, the student (level-1) variables (continuous and dummy coded variables) were added to the model to determine whether their relationship with student mathematics achievement varied significantly. Student background variables were entered and centered around the grand means. Table 4.5 presents the results of random-coefficient model for each predictor variable along with the variance components of within and between classrooms.

Random effects were individually checked and tested for each level-1 variable using the likelihood ratio test within *HLM v7*, and none of the random slopes were found to significantly improve model fit.

Table 4.5
Parameter Estimates for Chinese Taipei

	Null Model		Random-Coefficients Model		Full Model	
Fixed Effects	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	604.04	3.37	604.55**	3.05	604.15**	2.41
Student-level						
Student Gender			1.93	2.12	1.77	2.27
Confidence in math			17.38**	0.62	17.37**	0.75
Valuing math			3.47**	0.73	3.46**	0.85
Liking math			0.00	0.90	-0.07	0.95
Enjoying math			3.27**	0.56	3.25**	0.58
Time on homework			4.90	3.60	5.17	4.00
Time in tutorial			0.54	2.09	0.40	2.08
Computer access			-13.42**	2.00	-13.46**	1.87
Parental education			-0.32	2.05	-0.10	2.32
Own room			-5.73**	2.07	-5.96**	2.02
Classroom-level						
Teacher gender					0.61	5.16
Years of experience					0.75*	0.32
Major of study					0.24	4.78
Job satisfaction					1.45**	1.17
Class size					3.36	0.36
Number of computers					0.09	0.05

Variance Component	Estimate	Estimate	Estimate
Student-level	6177.88	4007.73	4009.91
Classroom-level	1802.22	1516.16	876.68

* $p < .05$.
** $p < .001$.

The full explanatory model was built by combining all student-level and classroom-level variables to predict mathematics achievement. According to the full model, statistically significant student-level predictors of mathematics achievement included confidence in learning mathematics, value in learning mathematics, enjoyment of mathematics, access to a computer and their own room to study at home. For each increase by 1 point in confidence in math, valuing of math, and enjoyment in learning math, mathematics achievement increased by an estimated 17.38, 3.47, and 3.27 points, respectively. This indicated that the average mathematics score of students who were more confident in, valued more, and enjoyed more learning mathematics was predicted to increase, especially for those who had more confidence in learning mathematics. Students who had access to a computer at home were predicted to score 13.42 points lower in mathematics achievement than those who did not have access to a computer. Students who had their own room to study in were predicted to score 5.73 points lower on mathematics achievement. When considering statistically significant level-2 predictors of mathematics achievement, the eighth-grade mathematics score increased by an estimated .85 point for each year increase in teacher experience. Likewise, an increase by 1 point in teacher job satisfaction increased the mathematics score increased by an estimated 1.45 points. Therefore, students who were in classrooms with experienced teachers who were satisfied in their job were estimated to score higher on eighth grade mathematics achievement in Chinese Taipei.

Results for Hong Kong

Table 4.6 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) continuous variables, conducted by using *SPSS* 24. Of the complete sample of 4249 eighth-grade students nested in 120 classrooms, on average, the overall mathematics achievement for Hong Kong students was 592.98 (*SD* = 76.34) with the range of 514.62 points. Furthermore, eighth-grade students in Hong Kong were on the upper half of having self-confidence in learning mathematics, valuing of mathematics, enjoying and liking in learning mathematics with the means of 9.41, 8.70, 9.88, and 9.50, respectively. At level-2, teacher years of experience showed a mean of 14.22 (*SD* = 9.43) ranging from one year to 38 years in the field. Teacher job satisfaction was in the upper half with a mean of 9.22 (*SD* = 1.89). Hong Kong classrooms, on average, presented a crowded learning environment with a mean of 30.64 (*SD* = 6.12). The average of number of available computers among the Hong Kong schools was 102.51 (*SD* = 71.99).

Table 4.7 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) categorical variables, conducted by using *SPSS* 24. At level-1, 52.90% of the participants was male and 46.90% was female. In terms of how much time Hong Kong students spent on homework, 85.70% of students responded that they spent less than 60 minutes while 11.90% spent more than 60 minutes. As for how much time they spent in tutorial, 34.80% said they spent less than 45 minutes while 64.00% answered that they spent more than 45 minutes after school. Computer access at home in Hong Kong divided into 63.40% owning of computer at home while 36.10% did not. More than half of the eighth-grade students responded that they had their own room to study at home. Parental education in Hong Kong presented 29.20% of the parents had a post-secondary education and above while 49.20% had below secondary education. A listwise deletion of missing cases was utilized in the analysis and resulted with 3280 students at the level-1 and 120 classrooms at level-2.

Table 4.6
Descriptive Statistics for Continuous Variables for Hong Kong

Variable	*N*	*Min*	*Max*	*Mean*	*SD*
Level 1					
Math achievement	4249	278.27	792.89	592.98	76.34
Valuing math	4222	3.00	13.65	8.70	1.95
Confidence in math	4214	3.20	15.93	9.41	2.21
Liking math	4226	4.97	13.98	9.50	1.95
Enjoying math	4219	3.77	13.62	9.88	2.0.1
Level 2					
Years of experience	120	1	38	14.22	9.43
Job satisfaction	120	4.73	12.79	9.22	1.89
Class size	120	2	43	30.64	6.21
Number of computers	120	0	500	102.51	71.99

Table 4.7
Descriptive Statistics for Categorical Variables for Hong Kong

Variable	*N*	*Percentage*
Student gender		
Male (0)	2249	52.90
Female (1)	1991	46.90
Missing	9	.20
Teacher gender		
Male (0)	2655	62.50
Female (1)	1542	36.30
Missing	52	1.20
Time on homework (minutes)		
60 or less (1)	3632	85.70
61 or more (0)	502	11.90
Missing	105	2.50
Time in tutorial (minutes)		
45 or less (1)	1479	34.80
46 or more (0)	2718	60.44
Missing	52	1.20
Computer access		
Yes (1)	2694	63.40
No (0)	1536	36.10
Missing	19	.40
Own room		
Yes (1)	2529	59.50
No (0)	1701	40.00
Missing	19	.40
Parental education		
Post-secondary (0)	1236	29.20
Secondary and below (1)	2094	49.20
Missing	919	21.60
Major of study		
Mathematics (0)	2662	62.60
Non-mathematics (1)	1469	34.50
Missing	118	2.80

Bivariate relationships between variables were examined at each level. Table 4.8 presents the correlations among student (level-1) variables. It appeared from these analyses that level-1 predictor variables were uncorrelated from each other except how students valued learning mathematics and students liked learning mathematics with a correlation $r = .56$ and their self-confidence in learning mathematics and liking learning mathematics with a correlation $r = .69$. Moreover, student time spent on homework negatively correlated with student time spent in tutorial, $r = -.65$. At the teacher and classroom (level-2), a bivariate relationship was also examined for five predictor variables.

Table 4.8
Bivariate Relationships between Level-1 Variables for Hong Kong

Variable	1	2	3	4	5	6	7	8	9	10
1. Student gender	1.00									
2. Confidence in math	-.01	1.00								
3. Valuing math	.03	.34	1.00							
4. Liking math	.01	.69	.56	1.00						
5. Enjoying math	.02	.13	.30	.25	1.00					
6. Time on homework	-.01	.18	.04	.13	.02	1.00				
7. Time in tutorial	.07	.09	-.03	.03	-.06	-.65	1.00			
8. Computer access	.12	-.01	.01	-.01	.00	-.03	.02	1.00		
9. Parental education	-.01	-.06	-.09	-.04	-.05	-.01	-.01	-.05	1.00	
10. Own room	.02	.02	.03	.01	.11	.04	.05	.18	-.16	1.00

Table 4.9 presents the correlation matrix for these variables. None of the level-2 variables was correlated to each other. To ensure tenability of results yielded by hierarchical linear modeling in this research, the assumptions of both level-1 and level-2 were verified congruently model buildings with the predictor variables. The descriptive statistics of both level variables presented an approximate normal distribution in combinations with their skewness and kurtosis values. The analysis also suggested that there was evidence of homogeneity of level-1 variance. The assumptions of normality and homogeneity of level-1 and level-2 random effects were satisfied.

Table 4.9

Bivariate Relationships between Level-2 Predictor Variables for Hong Kong

Variable	1	2	3	4	5	6
1. Teacher gender	1.00					
2. Years of experience	.06	1.00				
3. Major of study	-.02	-.07	1.00			
4. Job satisfaction	-.06	-.05	-.12	1.00		
5. Class size	.01	.07	.28	-.01	1.00	
6. Number of computers	-.07	-.09	.10	-.16	-.08	1.00

The unconditional model, in which none of the level-1 or level-2 predictor variables was included, was first built using Hierarchical Linear Modeling software *version* 7 (HLM *v*7). The fixed effect estimate of the intercept was 584.47 (*SE* = 5.90, $p < .001$). The average of mathematics achievement was significantly different across the classrooms in Hong Kong (τ_{00}= 4113.51, *SD* = 64.14, $p < .001$). Within classrooms, the amount of unexplained variance was smaller than the between classrooms (σ^2= 2373.59, *SD* = 48.72). The intra-class correlation (*ICC*) was then calculated using the formula,

$$ICC = \frac{\tau_{00}}{(\tau_{00} + \sigma^2)} = .63$$

The computed *ICC* of .63 represents the ratio of between-class variance and the total variance (within- and between-class variance) and indicated that 63% of the variance student mathematics achievement was between classes. That is, approximately 37% of the variance in student mathematics was attributed to student-level differences.

To answer the research questions, the student (level-1) variables (continuous and dummy coded variables) were added to the model to determine whether their relationship with student mathematics achievement varied significantly. Student background variables were entered and centered around the grand means. Table 4.10 presents the results of random-coefficients model

for each predictor variable along with the variance components of within and between class-rooms. Random effects were individually checked and tested for each level-1 variable using the likelihood ratio test within *HLM v7*, and none of the random slopes were found to significantly improve model fit.

Table 4.10
Parameter Estimates for Hong Kong

	Null model		Random-Coefficients Model		Full Model	
Fixed Effects	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	584.47	5.93**	548.73**	5.65	584.56**	4.68
Student-level						
Student Gender			1.55	1.57	1.64	1.57
Confidence in math			10.16**	0.48	10.14**	0.48
Valuing math			-0.56	0.48	-0.53	0.48
Liking math			3.03**	0.61	3.05**	0.61
Enjoying math			1.09**	0.40	1.09*	0.40
Time on homework			-5.28*	2.48	-5.34*	2.47
Time in tutorial			-4.15*	1.81	-4.68*	1.81
Computer access			-5.61**	1.56	-5.54**	1.56
Parental education			-4.74*	1.74	-4.68*	1.74
Own room			-4.96*	1.74	-4.93*	1.57
Classroom-level						
Teacher gender					27.28*	9.48
Years of experience					0.49	0.51
Major of study					-6.17	11.81
Job satisfaction					6.11*	2.59
Class size					4.43**	0.70
Number of computers					0.09	0.06

Variance components	Estimate	Estimate	Estimate
Student-level	2373.59	1704.49	1704.20
Classroom-level	4113.51	3763.62	2554.67

* $p < .05$.
** $p < .001$.

The full explanatory model was built by combining all student-level and classroom-level variables in the random-coefficient model to predict mathematics achievement. According to the full model, statistically significant student-level predictors of mathematics achievement included confidence in learning mathematics, like mathematics, enjoyment of mathematics, time on homework, time in tutorial, parental education, access to a computer and their own room to study at home. For each increase by 1 point in confidence in math, liking math and enjoyment in learning math, mathematics achievement increased by an estimated 10.16, 3.03, and 1.09 points, respectively. This indicated that the average mathematics score of students who were more confident, liked more, and enjoyed more learning mathematics was predicted to increase, especially for those who had more confidence in learning mathematics. Students who had access to a computer at home were predicted to score 5.6 points lower in mathematics achievement than those who did not have access to a computer. Students who had their own room to study in was predicted to score 5 points lower on math achievement than those who did not have their own room. Students who had parental education with secondary and below were predicted to score 4.74 points lower on math achievement than those who had parental education with postsecondary and above. Students who spent more than 60 minutes on homework and more than 45 minutes in tutorial were predicted to score 5.28 and 4.15 points, respectively, than those who spent did not. When considering statistically significant level-2 predictors of mathematics achievement, the eighth grade mathematics score increased by an estimated 27.28 point for students who had female teachers. Likewise, an increase by 1 point in teacher job satisfaction increases the mathematics score by an estimated 6.11 points. An increase in one student in the classrooms also dictated an increase of student mathematics score, on average, by 4.43 points. Therefore, students who were in classrooms with female teachers who were satisfied in their job and larger class size were estimated to score higher on eighth grade mathematics achievement in Hong Kong.

Results for Republic of Korea

Table 4.11 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) continuous variables, conducted by using *SPSS* 24. Of the complete sample of 5547 eighth-grade students nested in 170 classrooms, on average, the overall mathematics achievement for Korean students was 604.05 (*SD* = 82.00) with the range of 497.39 points. Furthermore, eighth-grade students in Korea were on the upper half of having self-confidence in learning mathematics, valuing of mathematics, enjoying and liking in learning mathematics with the means of 9.41, 8.58, 8.58, and 9.12, respectively. At level-2, teacher years of experience showed a mean of 14.15 (*SD* = 10.24) ranging from one year to 37 years in the field. Teacher job satisfaction was in the upper half with a mean of 9.54 (*SD* = 2.02). Korean classrooms, on average, presented a crowded learning environment with a mean of 31.84 (*SD* = 9.97). The average of number of available computers among the Korean schools was 45.78 (*SD* = 37.65).

Table 4.12 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) categorical variables, conducted by using *SPSS* 24. At level-1, 50.90% of the participants was male and 49.10% was female. In terms of how much time Korean students spent on homework, 64.90% of students responded that they spent less than 60 minutes while 5.50% spent more than 60 minutes. As for how much time they spent in tutorial, 80.80% said they spent less than 45 minutes while 18.90% answered that they spent more than 45 minutes after school. Computer access at home in Korea divided into 36.80% owning of computer at home while 63.00% did not. Three-fourth of the eighth-grade students responded that they had their own room to study at home. Parental education in Korea presented 49.10% of the parents had a post-secondary education and above while 28.00% had below secondary education. A listwise deletion of missing cases was utilized in the analysis and resulted with 4429 students at the level-1 and 170 classrooms at the level-2.

Table 4.11

Descriptive Statistics for Continuous Variables for Korea

Variable	*N*	*Min*	*Max*	*Mean*	*SD*
Level 1					
Math achievement	5547	340.75	838.14	604.05	82.00
Valuing math	5544	3.00	13.65	8.58	1.61
Confidence in math	5544	3.20	15.93	9.41	1.83
Liking math	5542	4.97	13.98	9.12	1.68
Enjoying math	5539	3.77	13.62	8.58	1.75
Level 2					
Years of experience	5547	1	37	14.15	10.24
Job satisfaction	5547	4.73	12.49	9.54	2.02
Class size	5547	3	72	31.84	9.97
Number of computers	5547	0	319	45.78	37.65

Table 4.12
Descriptive Statistics for Categorical Variables for Korea

Variable	*N*	*Percentage*
Student gender		
Male (0)	2822	50.90
Female (1)	2724	49.10
Missing	1	.00
Teacher gender		
Male (0)	1613	29.10
Female (1)	3934	70.90
Missing	0	0
Time on homework (minutes)		
60 or less (1)	4125	74.90
61 or more (0)	307	5.50
Missing	1088	19.60
Time in tutorial (minutes)		
45 or less (1)	4483	80.80
46 or more (0)	1050	18.90
Missing	14	.30
Computer access		
Yes (1)	2044	36.80
No (0)	3497	63.00
Missing	6	.10
Own room		
Yes (1)	4051	73.00
No (0)	1490	26.90
Missing	6	.10
Parental education		
Post-secondary (0)	2724	49.10
Secondary and below (1)	1556	28.00
Missing	1267	22.90
Major of study		
Mathematics (0)	2695	48.5
Non-mathematics (1)	2852	51.50

Bivariate relationships between variables were examined at each level. Table 4.13 presents the correlations among student (level-1) variables. It appeared from these analyses that level-1 predictor variables were uncorrelated from each other except students valued learning mathematics was moderately correlated with students liked learning mathematics, $r = .55$. Moreover, student valuing in learning mathematics was moderately correlated ($r = .56$) with having access to computer at home. At the teacher and classroom (level-2), a bivariate relationship was also examined for five predictor variables.

Table 4.13
Bivariate Relationships between Level-1 Variables for Korea

Variable	1	2	3	4	5	6	7	8	9	10
1. Student gender	1.00									
2. Confidence in math	-.13	1.00								
3. Valuing math	-.08	.04	1.00							
4. Liking math	-.09	.07	.55	1.00						
5. Enjoying math	-.11	.28	.40	.40	1.00					
6. Time on homework	.00	.14	.03	.12	.01	1.00				
7. Time in tutorial	.01	.08	.00	.05	.01	-.03	1.00			
8. Computer access	-.06	.03	.56	.35	.03	.02	.03	1.00		
9. Parental education	.01	-.16	-.17	-.09	-.14	.01	-.01	.02	1.00	
10. Own room	-.05	.10	.06	.06	.04	-.03	.06	.13	.02	1.00

Table 4.14 presents the correlation matrix for these variables. None of the level-2 variables was correlated to each other. To ensure tenability of results yielded by hierarchical linear modeling in this research, the assumptions of both level-1 and level-2 were verified congruently model buildings with the predictor variables. The descriptive statistics of both level variables presented an approximate normal distribution in combinations with their skewness and kurtosis values. The analysis also suggested that there was evidence of homogeneity of level-1 variance. The assumptions of normality and homogeneity of level-1 and level-2 random effects were satisfied.

Table 4.14

Bivariate Relationships between Level-2 Predictor Variables for Korea

Variable	1	2	3	4	5	6
1. Teacher gender	1.00					
2. Years of experience	-.11	1.00				
3. Major of study	-.02	-.01	1.00			
4. Job satisfaction	.01	-.23	-.02	1.00		
5. Class size	.05	-.02	-.01	-.11	1.00	
6. Number of computers	.03	-.02	-.01	.03	-.02	1.00

The unconditional model, in which none of the level-1 or level-2 predictor variables was included, was first built using Hierarchical Linear Modeling software *version* 7 (HLM *v*7). The fixed effect estimate of the intercept was 6065.17 (*SE* = 2.27, p < .001). The average of mathematics achievement was significantly different across the classrooms in Korea (τ_{00}= 635.81, *SD* = 25.22, p < .001). Within classrooms, the amount of unexplained variance was smaller than the between classrooms (σ^2= 5852.28, *SD* = 76.50). The intra-class correlation (*ICC*) was then calculated using the formula,

$$ICC = \frac{\tau_{00}}{(\tau_{00} + \sigma^2)} = .10$$

The computed *ICC* of .10 represents the ratio of between-class variance and the total variance (within- and between-class variance) and indicated that 10% of the variance student mathematics achievement was between classes. That is, approximately 90% of the variance in student mathematics was attributed to student-level differences.

To answer the research questions, the student (level-1) variables (continuous and dummy coded variables) were added to the model to determine whether their relationship with student mathematics achievement varied significantly. Student background variables were entered and centered around the grand means. Table 4.15 presents the results of random-coefficients model

for each predictor variable along with the variance components of within and between classrooms. Random effects were individually checked and tested for each level-1 variable using the likelihood ratio test within *HLM v7*, and none of the random slopes were found to significantly improve model fit.

Table 4.15
Parameter Estimates for Korea

	Null model		Random-Coefficients Model		Full Model	
Fixed Effects	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	605.17	2.27	605.49**	1.73	605.20**	1.72
Student-level						
Student Gender			9.23**	2.52	9.25**	2.52
Confidence in math			19.97**	0.74	19.92**	0.74
Valuing math			5.83**	0.76	5.83**	0.76
Liking math			-0.97	0.88	-0.89	0.88
Enjoying math			4.34**	0.63	4.32**	0.63
Time on homework			1.19	4.08	1.31	4.07
Time in tutorial			4.01	2.44	3.87	2.43
Computer access			-16.95**	2.00	-16.84**	1.99
Parental education			-20.84**	2.04	-20.71**	2.04
Own room			0.08	2.20	-0.19	2.20
Classroom-level						
Teacher gender					-1.84	3.93
Years of experience					-0.24	0.18
Major of study					71.10*	33.88
Job satisfaction					1.00	0.87
Class size					0.20	0.17
Number of computers					-0.04	0.04
Variance components	Estimate		Estimate		Estimate	
Student-level	5852.28		3864.77		3862.79	
Classroom-level	635.81		305.18		340.64	

* $p < .05$.
** $p < .001$.

The full explanatory model was built by combining all student-level and classroom-level variables to predict mathematics achievement. According to the full model, statistically significant student-level predictors of mathematics achievement included student gender, confidence in learning mathematics, value in learning mathematics, enjoyment of mathematics, parental educational, and access to a computer at home. On average, female students were predicted to perform 9.23 points higher than male students in Korea. For each increase by 1 point in confidence in math, valuing of math, and enjoyment in learning mathematics, mathematics achievement increased by an estimated by 19.97, 5.83, and 4.34 points, respectively. This indicated that the average mathematics score of students who were more confident in, valued more, and enjoyed more learning mathematics was predicted to increase, especially for those who had more confidence in learning mathematics. Students who had access to a computer at home were predicted to score 16.95 points lower than those who did not have access to a computer. Students who had parental education with secondary and below were predicted to score 20.84 points lower than those who had parental education with postsecondary and above. When considering statistically significant level-2 predictors of mathematics achievement, the eighth grade mathematics score increased by an estimated 71.10 points for those students who had teachers with non-mathematics major.

Results for Japan

Table 4.16 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) continuous variables, conducted by using *SPSS* 24. Of the complete sample of 6375 eighth-grade students nested in 144 classrooms, on average, the overall mathematics achievement for Japanese students was 587.22 (*SD* = 86.48) with the range of 559.98 points. Furthermore, eighth-grade students in Japan were on the upper half of having self-confidence in learning mathematics, valuing of mathematics, enjoying and liking in learning mathematics with the means of 8.97, 8.47, 9.04, and 9.21, respectively. At level-2, teacher years of experience showed a mean of 16.62 (*SD* = 11.86) ranging from one year to 41 years in the field. Teacher job satisfaction was in the upper half with a mean of 9.01 (*SD* = 2.00). Japanese classrooms, on average, presented a crowded learning environment with a mean of 33.19 (*SD* = 6.71). The average of number of available computers among the Japanese schools was 46.30 (*SD* = 25.87).

Table 4.17 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) categorical variables, conducted by using *SPSS* 24. At level-1, 49.10% of the participants was male and 50.90% was female. In terms of how much time Japanese students spent on homework, 81.00% of students responded that they spent less than 60 minutes while 3.90% spent more than 60 minutes. As for how much time they spent in tutorial, 68.6% said they spent less than 45 minutes while 26.00% answered that they spent more than 45 minutes after school. Computer access at home in Japan divided into 55.30% owning of computer at home while 44.30% did not. More than four-fifth of the eighth-grade students responded that they had their own room to study at home. Parental education in Japan presented 52.70% of the parents had a post-secondary education and above while 41.10% had below secondary education. A listwise deletion of missing cases was utilized in the analysis and resulted with 3730 students at the level-1 and 144 classrooms at level-2.

Table 4.16
Descriptive Statistics for Continuous Variables for Japan

Variable	*N*	*Min*	*Max*	*Mean*	*SD*
Level 1					
Math achievement	6375	278.51	838.49	587.22	86.48
Valuing math	6365	3.00	13.65	8.47	1.49
Confidence in math	6365	3.20	15.93	8.97	1.96
Liking math	6365	4.97	13.98	9.21	1.66
Enjoying math	6367	3.77	13.62	9.04	1.78
Level 2					
Years of experience	6313	1	41	16.62	11.86
Job satisfaction	6289	4.73	12.49	9.01	2.00
Class size	6288	1	46	33.19	6.71
Number of computers	6315	0	160	46.30	25.87

Table 4.17

Descriptive Statistics for Categorical Variables for Japan

Variable	*N*	*Percentage*
Student gender		
Male (0)	3130	49.10
Female (1)	3242	50.90
Missing	3	.00
Teacher gender		
Male (0)	4420	69.30
Female (1)	1925	30.20
Missing	30	.50
Time on homework (minutes)		
60 or less (1)	5164	81.00
61 or more (0)	251	3.90
Missing	744	11.70
Time in tutorial (minutes)		
45 or less (1)	4376	68.60
46 or more (0)	1685	26.00
Missing	341	5.30
Computer access		
Yes (1)	3527	55.30
No (0)	2827	44.30
Missing	21	.30
Own room		
Yes (1)	5307	83.20
No (0)	1056	16.60
Missing	12	.20
Parental education		
Post-secondary (0)	3362	52.70
Secondary and below (1)	1546	41.10
Missing	1467	23.00
Major of study		
Mathematics (0)	5162	73.40
Non-mathematics (1)	1183	18.60
Missing	30	.50

Bivariate relationships between variables were examined at each level. Table 4.18 presents the correlations among student (level-1) variables. It appeared from these analyses that level-1 predictor variables were uncorrelated from each other except students liked learning mathematics positively correlated with their self-confidence in learning mathematics, $r = .73$. At the teacher and classroom (level-2), a bivariate relationship was also examined for five predictor variables.

Table 4.18

Bivariate Relationships between Level-1 Variables for Japan

Variable	1	2	3	4	5	6	7	8	9	10
1. Student gender	1.00									
2. Confidence in math	.01	1.00								
3. Valuing math	.00	.30	1.00							
4. Liking math	.02	.73	.04	1.00						
5. Enjoying math	.00	.24	.30	.04	1.00					
6. Time on homework	-.02	.14	.04	-.12	.05	1.00				
7. Time in tutorial	.02	.01	-.03	.00	.01	.01	1.00			
8. Computer access	-.01	.01	-.01	-.01	.0	-.03	-.01	1.00		
9. Parental education	-.02	.00	.03	.03	.02	.03	.03	.03	1.00	
10. Own room	-.01	.03	.00	-.03	-.01	.04	-.02	.06	-.01	1.00

Table 4.19 presents the correlation matrix for these variables. None of the level-2 variables was correlated to each other. To ensure tenability of results yielded by hierarchical linear modeling in this research, the assumptions of both level-1 and level-2 were verified congruently model buildings with the predictor variables. The descriptive statistics of both level variables presented an approximate normal distribution in combinations with their skewness and kurtosis values. The analysis also suggested that there was evidence of homogeneity of level-1 variance. The assumptions of normality and homogeneity of level-1 and level-2 random effects were satisfied.

Table 4.19
Bivariate Relationships between Level-2 Predictor Variables for Japan

Variable	1	2	3	4	5	6
1. Teacher gender	1.00					
2. Years of experience	-.03	1.00				
3. Major of study	.14	-.05	1.00			
4. Job satisfaction	-.03	-.07	.01	1.00		
5. Class size	-.04	-.05	.05	.05	1.00	
6. Number of computers	.02	..06	-.04	-.06	.07	1.00

The unconditional model, in which none of the level-1 or level-2 predictor variables was included, was first built using Hierarchical Linear Modeling software *version* 7 (HLM *v*7). The fixed effect estimate of the intercept was 587.34 (*SE* = 3.45, *p* < .001). The average of mathematics achievement was significantly different across the classrooms in Japan (τ_{00}= 1442.35, *SD* = 37.98, *p* < .001). Within classrooms, the amount of unexplained variance was smaller than the between classrooms (σ^2= 5563.30, *SD* = 74.59). The intra-class correlation (*ICC*) was then calculated using the formula,

$$ICC = \frac{\tau_{00}}{(\tau_{00} + \sigma^2)} = .21$$

The computed *ICC* of .21 represents the ratio of between-class variance and the total variance (within- and between-class variance) and indicated that 21% of the variance of student mathematics achievement was between classes. That is, approximately 79% of the variance in student mathematics was attributed to student-level differences.

To answer the research questions, the student (level-1) variables (continuous and dummy coded variables) were added to the model to determine whether their relationship with student mathematics achievement varied significantly. Student background variables were entered and centered around the grand means. Table 4.20 presents the results of random-coefficients mode for each predictor variable along with the variance components of within and between classrooms. Random effects were individually checked and tested for each level-1 variable using the likelihood ratio test within *HLM v7*, and none of the random slopes were found to significantly improve the model fit.

Table 4.20
Parameter Estimates for Japan

Fixed Effects	Null model		Random-Coefficients Model		Full Model	
	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	587.34	3.44	586.95**	3.33	586.72**	2.93
Student-level						
Student Gender			-0.53	2.19	-0.41	2.19
Confidence in math			18.65**	0.82	18.67**	0.82
Valuing math			3.18**	0.84	3.22**	0.84
Liking math			0.41	1.08	0.45	1.08
Enjoying math			1.97*	0.72	1.99*	0.72
Time on homework			3.06	4.32	3.45	4.31
Time in tutorial			1.23	2.45	0.98	2.45
Computer access			-9.55**	2.16	-9.70**	2.16
Parental education			-2.55	2.34	-2.56	2.34
Own room			-1.80	2.90	-1.69	2.90
Classroom-level						
Teacher gender					-4.23	20.81
Years of experience					0.46	0.26
Major of study					-2.77	13.97
Job satisfaction					-0.37	1.57
Class size					0.48	0.42
Number of computers					0.81**	0.13

Variance components	Null model Estimate	Random-Coefficients Model Estimate	Full Model Estimate
Student-level	5563.30	4039.90	4040.18
Classroom-level	1442.35	1395.73	1031.29

* $p < .05$.
** $p < .001$.

The full explanatory model was built by combining all student-level and classroom-level variables to predict mathematics achievement. According to the full model, statistically significant student-level predictors of mathematics achievement included confidence in learning mathematics, value in learning mathematics, enjoyment in learning mathematics, and access to a computer at home. For each increase by 1 point in confidence in math, valuing of math and enjoyment in learning mathematics, mathematics achievement increased by an estimated 18.65, 3.18, and 1.97 points, respectively. This indicated that the average mathematics score of students who were more confident in, valued more, and enjoyed more learning mathematics was predicted to increase, especially for those who had more confidence in learning mathematics. Students who had access to a computer at home were predicted to score 9.55 points lower on math achievement than those who did not have access to a computer. When considering statistically significant level-2 predictors of mathematics achievement, the eighth grade mathematics score increased by an estimated .81 for each available computer increase.

Results for Malaysia

Table 4.21 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) continuous variables, conducted by using *SPSS* 24. Of the complete sample of 9726 eighth-grade students nested in 276 classrooms, on average, the overall mathematics achievement for Malaysian students was 501.57 (SD = 86.46) with the range of 487 points. Furthermore, eighth-grade students in Malaysia were on the upper half of having self-confidence in learning mathematics, valuing of mathematics, enjoying and liking in learning mathematics with the means of 9.61, 10.10, 11.05, and 10.83, respectively. At level-2, teacher years of experience showed a mean of 12.52 (SD = 8.32) ranging from one year to 36 years in the field. Teacher job satisfaction was in the upper half with a mean of 10.54 (SD = 1.71). Malaysian classrooms, on average, presented a crowded learning environment with a mean of 32.33 (*SD* = 8.02). The average of number of available computers among the Malaysian schools was 47.22 (*SD* = 82.39).

Table 4.22 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) categorical variables, conducted by using *SPSS* 24. At level-1, 48.40% of the participants was male and 51.60% was female. In terms of how much time Malaysian students spent on homework, 78.70% of students responded that they spent less than 60 minutes while 16.80% spent more than 60 minutes. As for how much time they spent in tutorial, 25.70% said they spent less than 45 minutes while 70.60% answered that they spent more than 45 minutes after school. Computer access at home in Malaysia divided into 38.40% owning of computer at home while 61.10% did not. About two-third of the eighth-grade students responded that they had their own room to study at home. Parental education in Malaysia presented 34.70% of the parents had a post-secondary education and above while 43.20% had below secondary education. A listwise deletion of missing cases was utilized in the analysis and resulted with 6114 students at the level-1 and 276 classrooms at the level-2.

Table 4.21
Descriptive Statistics for Continuous Variables for Malaysia

Variable	*N*	*Min*	*Max*	*Mean*	*SD*
Level 1					
Math achievement	9726	254.07	741.07	501.57	86.46
Valuing math	9636	3.00	13.65	10.10	1.74
Confidence in math	9665	3.20	15.93	9.61	1.47
Liking math	9705	4.97	13.98	10.83	1.46
Enjoying math	9615	3.77	13.62	11.05	1.81
Level 2					
Years of experience	8991	1	36	12.52	8.32
Job satisfaction	8986	5.84	12.49	10.54	1.71
Class size	8957	4	77	32.33	8.02
Number of computers	9334	0	1041	47.22	82.39

Table 4.22
Descriptive Statistics for Categorical Variables for Malaysia

Variable	*N*	*Percentage*
Student gender		
Male (0)	4710	48.4
Female (1)	5014	51.60
Missing	2	.00
Teacher gender		
Male (0)	2197	22.60
Female (1)	6889	70.80
Missing	640	6.60
Time on homework (minutes)		
60 or less (1)	7661	78.70
61 or more (0)	1628	16.80
Missing	437	4.50
Time in tutorial (minutes)		
45 or less (1)	2502	25.70
46 or more (0)	6871	70.60
Missing	353	3.60
Computer access		
Yes (1)	3739	38.40
No (0)	5945	61.10
Missing	42	.40
Own room		
Yes (1)	6399	65.80
No (0)	3293	33.90
Missing	34	.30
Parental education		
Post-secondary (0)	3368	34.70
Secondary and below (1)	4194	43.20
Missing	2164	22.30
Major of study		
Mathematics (0)	5142	52.90
Non-mathematics (1)	3703	38.10
Missing	881	9.10

Bivariate relationships between variables were examined at each level. Table 4.23 presents the correlations among student (level-1) variables. It appeared from these analyses that level-1 predictor variables were uncorrelated from each other except how students liked learning mathematics with their self-confidence in learning mathematics, *r* = .65. At the teacher and classroom (level-2), a bivariate relationship was also examined for five predictor variables.

Table 4.23
Bivariate Relationships between Level-1 Variables for Malaysia

Variable	1	2	3	4	5	6	7	8	9	10
1. Student gender	1.00									
2. Confidence in math	-.07	1.00								
3. Valuing math	.06	.34	1.00							
4. Liking math	.05	.65	.05	1.00						
5. Enjoying math	.02	.08	.04	.29	1.00					
6. Time on homework	-.05	.19	.02	.12	-.05	1.00				
7. Time in tutorial	-.07	.06	-.06	.00	-.11	.24	1.00			
8. Computer access	-.04	.02	.05	-.02	.02	-.01	.02	1.00		
9. Parental education	.09	-.07	-.11	-.05	-.08	-.01	.02	-.11	1.00	
10. Own room	.00	.01	.04	.03	.07	.01	.00	.12	-.11	1.00

Table 4.24 presents the correlation matrix for these variables. None of the level-2 variables was correlated to each other. To ensure tenability of results yielded by hierarchical linear modeling in this research, the assumptions of both level-1 and level-2 were verified congruently model buildings with the predictor variables. The descriptive statistics of both level variables presented an approximate normal distribution in combinations with their skewness and kurtosis values. The analysis also suggested that there was evidence of homogeneity of level-1 variance. The assumptions of normality and homogeneity of level-1 and level-2 random effects were satisfied.

Table 4.24
Bivariate Relationships between Level-2 Predictor Variables for Malaysia

Variable	1	2	3	4	5	6
1. Teacher gender	1.00					
2. Years of experience	.14	1.00				
3. Major of study	-.03	-.05	1.00			
4. Job satisfaction	-.03	-.07	.01	1.00		
5. Class size	-.04	-.05	.05	.05	1.00	
6. Number of computers	.02	-.04	-.04	-.06	.07	1.00

The unconditional model, in which none of the level-1 or level-2 predictor variables was included, was first built using Hierarchical Linear Modeling software *version* 7 (HLM *v*7). The fixed effect estimate of the intercept was 502.65 (*SE* = 4.52, $p < .001$). The average of mathematics achievement was significantly different across the classrooms in Malaysia (τ_{00}= 5536.93, *SD* = 74.41, $p < .001$). Within classrooms, the amount of unexplained variance was smaller than the between classrooms (σ^2= 1867.72, *SD* = 43.22). The intra-class correlation (*ICC*) was then calculated using the formula,

$$ICC = \frac{\tau_{00}}{(\tau_{00} + \sigma^2)} = .75$$

The computed *ICC* of .75 represents the ratio of between-class variance and the total variance (within- and between-class variance) and indicated that 75% of the variance student mathematics achievement was between classes. That is, approximately 25% of the variance in student mathematics was attributed to student-level differences.

To answer the research questions, the student (level-1) variables (continuous and dummy coded variables) were added to the model to determine whether their relationship with student mathematics achievement varied significantly. Student background variables were entered and centered around the grand means. Table 4.25 presents the results of random-coefficients model

for each predictor variable along with the variance components of within and between classrooms. Random effects were individually checked and tested for each level-1 variable using the likelihood ratio test within *HLM v7*, and none of the random slopes were found to significantly improve the model fits.

Table 4.25
Parameter Estimates for Malaysia

	Null model		Random-Coefficients Model		Full Model	
Fixed Effects	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	502.65	4.52	502.79**	4.37	502.79**	4.34
Student-level						
Student Gender			-6.74**	1.09	-6.72**	1.09
Confidence in math			12.44**	0.46	12.43**	0.46
Valuing math			-0.12	0.36	-0.13	0.36
Liking math			2.31**	0.54	2.31**	0.54
Enjoying math			-2.91**	0.32	-2.91**	0.32
Time on homework			0.96	1.39	0.96	1.39
Time in tutorial			1.26	1.24	1.27	1.24
Computer access			-2.06*	1.05	-2.07*	1.05
Parental education			-2.75*	1.11	-2.72*	1.11
Own room			-6.59**	1.09	-6.59**	1.09
Classroom-level						
Teacher gender					-0.30	10.57
Years of experience					-0.12	0.54
Major of study					-16.25	9.69
Job satisfaction					2.86	2.63
Class size					-0.08	0.57
Number of computers					0.12*	0.05
Variance components	Estimate		Estimate		Estimate	
Student-level	1867.72		1428.65		1429.65	
Classroom-level	5536.93		5186.42		5117.03	

* $p < .05$.
** $p < .001$.

The full explanatory model was built by combining all student-level and classroom-level variables to predict mathematics achievement. According to the full model, statistically significant student-level predictors of mathematics achievement included confidence in learning mathematics, value in learning mathematics, enjoyment of mathematics, and access to a computer at home. For each increase by 1 point in confidence in math, valuing of math, and enjoyment in learning math, mathematics achievement increased by an estimated 18.65, 3.18, and 1.97 points, respectively. This indicated that the average mathematics score of students who were more confident in, valued more, and enjoyed more learning mathematics was predicted to increase, especially for those who had more confident in learning mathematics. Students who had access to a computer at home were predicted to score 9.55 points lower in mathematics achievement than those who did not have access to a computer. When considering statistically significant level-2 predictors of mathematics achievement, the eighth grade mathematics score increased by an estimated .81 point for each available computer increase at school.

Results for Singapore

Table 4.26 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) continuous variables, conducted by using *SPSS* 24. Of the complete sample of 6116 eighth-grade students nested in 321 classrooms, on average, the overall mathematics achievement for Singapore students was 616.06 (*SD* = 80.82) with the range of 451.52 points. Furthermore, eighth-grade students in Singapore were on the upper half of having self-confidence in learning mathematics, valuing of mathematics, enjoying and liking in learning mathematics with the means of 9.72, 9.67, 10.28, and 10.13, respectively. At level-2, teacher years of experience showed a mean of 8.79 (*SD* = 8.52) ranging from one year to 46 years in the field. Teacher job satisfaction was in the upper half with a mean of 9.13 (*SD* = 2.22). Singapore classrooms, on average, presented a crowded learning environment with a mean of 35.45 (*SD* = 6.61). The average of number of available computers among the Singapore schools was 231.95 (*SD* = 120.47).

Table 4.27 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) categorical variables, conducted by using *SPSS* 24. At level-1, 51.30% of the participants was male and 48.70% was female. In terms of how much time Singapore students spent on homework, 81.60% of students responded that they spent less than 60 minutes while 16.80% spent more than 60 minutes. As for how much time they spent in tutorial, 23.70% said they spent less than 45 minutes while 75.70% answered that they spent more than 45 minutes after school. Computer access at home in Singapore divided into 65.30% owning of computer at home while 34.60% did not. More than half of the eighth-grade students responded that they had their own room to study at home. Parental education in Singapore presented 51.10% of the parents had a post-secondary education and above while 25.30% had below secondary education. A listwise deletion of missing cases was utilized in the analysis and resulted with 4411 students at the level-1 and 321 classrooms at the level-2.

Table 4.26
Descriptive Statistics for Continuous Variables for Singapore

Variable	*N*	*Min*	*Max*	*Mean*	*SD*
Level 1					
Math achievement	6116	349.33	800.85	616.06	80.82
Valuing math	6086	3.00	13.65	9.67	1.73
Confidence in math	6088	3.20	15.93	9.72	3.17
Liking math	6089	4.97	13.98	10.13	1.88
Enjoying math	6084	3.77	13.62	10.28	2.01
Level 2					
Years of experience	6043	1	46	8.79	8.52
Job satisfaction	6005	4.73	12.79	9.13	2.22
Class size	6043	5	44	35.45	6.61
Number of computers	5978	45	800	231.95	120.47

Table 4.27
Descriptive Statistics for Categorical Variables for Singapore

Variable	*N*	*Percentage*
Student gender		
Male (0)	3136	51.30
Female (1)	2977	48.70
Missing	3	.00
Teacher gender		
Male (0)	2292	37.50
Female (1)	3751	61.30
Missing	73	1.20
Time on homework (minutes)		
60 or less (1)	4994	81.60
61 or more (0)	1029	16.80
Missing	93	1.60
Time in tutorial (minutes)		
45 or less (1)	1450	23.70
46 or more (0)	4632	75.70
Missing	34	.60
Computer access		
Yes (1)	3991	65.30
No (0)	2114	34.60
Missing	11	.20
Own room		
Yes (1)	3177	51.90
No (0)	2927	47.90
Missing	12	.20
Parental education		
Post-secondary (0)	3129	51.1
Secondary and below (1)	1542	25.30
Missing	1445	23.70
Major of study		
Mathematics (0)	5091	83.30
Non-mathematics (1)	952	15.5
Missing	73	1.20

Bivariate relationships between variables were examined at each level. Table 4.28 presents the correlations among student (level-1) variables. It appeared from these analyses that level-1 predictor variables were uncorrelated from each other except how students liked learning mathematics with their self-confidence in learning mathematics, *r* = .71. At the teacher and classroom (level-2), a bivariate relationship was also examined for five predictor variables.

Table 4.28

Bivariate Relationships between Level-1 Variables for Singapore

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1. Student gender	1.00									
2. Confidence in math	-.11	1.00								
3. Valuing math	-.06	.37	1.00							
4. Liking math	-.05	.71	.05	1.00						
5. Enjoying math	-.14	.13	.24	.19	1.00					
6. Time on homework	-.07	.17	.01	.10	-.03	1.00				
7. Time in tutorial	-.10	.05	-.06	-.03	-.04	.22	1.00			
8. Computer access	-.06	.06	.02	.00	.07	.01	.00	1.00		
9. Parental education	.03	-.09	-.05	-.05	-.11	.02	.05	-.06	1.00	
10. Own room	-.04	.05	.03	.02	.02	.02	.01	.19	-.16	1.00

Table 4.29 presents the correlation matrix for these variables. None of the level-2 variables was correlated to each other. To ensure tenability of results yielded by hierarchical linear modeling in this research, the assumptions of both level-1 and level-2 were verified congruently model buildings with the predictor variables. The descriptive statistics of both level variables presented an approximate normal distribution in combinations with their skewness and kurtosis values. The analysis also suggested that there was evidence of homogeneity of level-1 variance. The assumptions of normality and homogeneity of level-1 and level-2 random effects were satisfied.

Table 4.29

Bivariate Relationships between Level-2 Predictor Variables for Singapore

Variable	*1*	*2*	*3*	*4*	*5*	*6*
1. Teacher gender	1.00					
2. Years of experience	.09	1.00				
3. Major of study	.01	-.02	1.00			
4. Job satisfaction	.00	.14	.09	1.00		
5. Class size	-.01	-.07	-.01	-.13	1.00	
6. Number of computers	-.05	-.05	.04	.02	.11	1.00

The unconditional model, in which none of the level-1 or level-2 predictor variables was included, was first built using Hierarchical Linear Modeling software *version* 7 (HLM *v*7). The fixed effect estimate of the intercept was 614.65 (*SE* = 4.15, $p < .001$). The average of mathematics achievement was significantly different across the classrooms in Singapore (τ_{00}= 5447.28, *SD* = 73.81, $p < .001$). Within classrooms, the amount of unexplained variance was smaller than the between classrooms (σ^2= 1126.64, *SD* = 33.57). The intra-class correlation (*ICC*) was then calculated using the formula,

$$ICC = \frac{\tau_{00}}{(\tau_{00} + \sigma^2)} = .83$$

The computed *ICC* of .83 represents the ratio of between-class variance and the total variance (within- and between-class variance) and indicated that 83% of the variance student mathematics achievement was between classes. That is, approximately 17% of the variance in student mathematics was attributed to student-level differences.

To answer the research questions, the student (level-1) variables (continuous and dummy coded variables) were added to the model to determine whether their relationship with student mathematics achievement varied significantly. Student background variables were entered and centered around the grand means. Table 4.30 presents the results of random-coefficients model

for each predictor variable along with the variance components of within and between classrooms. Random effects were individually checked and tested for each level-1 variable using the likelihood ratio test within *HLM v7*, and none of the random slopes were found to significantly improve the model fit.

Table 4.30
Parameter Estimates for Singapore

	Null model		Random-Coefficients Model		Full Model	
Fixed Effects	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	614.65	4.15	615.08**	3.97	604.15**	2.41
Student-level						
Student Gender			-2.44*	1.01	-2.48*	1.01
Confidence in math			7.40**	0.30	7.39**	0.30
Valuing math			-0.41	0.32	-0.40	0.32
Liking math			1.56**	0.38	1.56**	0.38
Enjoying math			0.74*	0.24	0.74*	0.24
Time on homework			-1.45	1.26	-1.46	1.26
Time in tutorial			2.18	1.21	2.22	1.21
Computer access			-3.19**	0.99	-3.18**	0.99
Parental education			0.05	1.02	0.06	1.02
Own room			-2.85*	0.93	-2.94*	0.93
Classroom-level						
Teacher gender					25.30*	8.01
Years of experience					0.15	0.46
Major of study					7.19	8.40
Job satisfaction					2.56	1.77
Class size					1.55*	0.59
Number of computers					0.07*	0.03
Variance components	Estimate		Estimate		Estimate	
Student-level	1126.64		813.42		813.37	
Classroom-level	5447.28		5005.09		4720.23	

* $p < .05$.
** $p < .001$.

The full explanatory model was built by combining all student-level and classroom-level variables to predict mathematics achievement. According to the full model, statistically significant student-level predictors of mathematics achievement included student gender, confidence in learning mathematics, like learning mathematics, enjoyment of mathematics, access to a computer and their own room to study at home. Male students, on average, were predicted to achieve 2.44 points higher than female students on the mathematics assessment. For each increase by 1 point in confidence in math, liking math, and enjoyment in learning math, mathematics achievement increased by an estimated 7.40, 1.56, and .74 points, respectively. This indicated that the average mathematics score of students who were more confident in, liked more, and enjoyed more learning mathematics was predicted to increase, especially for those who had more confident in learning mathematics. Students who had access to a computer at home were predicted to score 3.19 points lower in mathematics achievement than those who did not have access to a computer. Students who had their own room to study in were predicted to score 2.85 points lower on math achievement than those who did not have their own room. When considering statistically significant level-2 predictors of mathematics achievement, the eighth grade mathematics score increased by an estimated 1.55 points for each one student increase in the class. Also, students who had female teacher were predicted to score 25.3 points higher on math achievement than those who did not have. Therefore, students who were in a crowded classroom with a female teacher were estimated to score higher on eighth grade mathematics achievement in Singapore. Although the number of computers estimate was significant in the full model, the effect was too low (.07) to report.

Results for Thailand

Table 4.31 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) continuous variables, conducted by using *SPSS* 24. Of the complete sample of 6482 eighth-grade students nested in 187 classrooms, on average, the overall mathematics achievement for Thailand students was 449.57 (*SD* = 96.34) with the range of 567.71 points. Furthermore, eighth-grade students in Thailand were on the upper half of having self-confidence in learning mathematics, valuing of mathematics, enjoying and liking in learning mathematics with the means of 9.16, 10.33. 10.30, and 10.30, respectively. At level-2, teacher years of experience showed a mean of 12.61 (*SD* = 11.50) ranging from one year to 40 years in the field. Teacher job satisfaction was in the upper half with a mean of 10.75 (*SD* = 1.64). Thailand classrooms, on average, presented a crowded learning environment with a mean of 35.73 (*SD* = 10.14). The average of number of available computers among the Thailand schools was 226.84 (*SD* = 224.64).

Table 4.32 presents a descriptive examination of student (level-1) and teacher/classroom (level-2) categorical variables, conducted by using *SPSS* 24. At level-1, 45.90% of the participants was male and 54.10% was female. In terms of how much time Thai students spent on homework, 85.60% of students responded that they spent less than 60 minutes while 20.00% spent more than 60 minutes. As for how much time they spent in tutorial, 26.50% said they spent less than 45 minutes while 72.50% answered that they spent more than 45 minutes after school. Computer access at home in Thailand divided into 69.90% owning of computer at home while 29.70% did not. Approximately, two-third of the eighth-grade students responded that they had their own room to study at home. Parental education in Thailand presented 31.90% of the parents had a post-secondary education and above while 50.10% had below secondary education. A listwise deletion of missing cases was utilized in the analysis and resulted with 4514 students at the level-1 and 187 classrooms at the level-2.

Table 4.31
Descriptive Statistics for Continuous Variables for Thailand

Variable	*N*	*Min*	*Max*	*Mean*	*SD*
Level 1					
Math achievement	6482	212.66	780.37	449.57	96.34
Valuing math	6420	3.00	13.65	10.33	1.82
Confidence in math	6444	3.20	15.93	9.16	1.52
Liking math	6459	4.97	13.98	10.30	1.43
Enjoying math	6421	3.77	13.62	10.30	1.70
Level 2					
Years of experience	6311	1	40	12.61	11.50
Job satisfaction	6453	4.73	12.49	10.75	1.64
Class size	6482	5	62	35.73	10.14
Number of computers	5906	0	930	226.84	224.64

Table 4.32
Descriptive Statistics for Categorical Variables for Thailand

Variable	*N*	*Percentage*
Student gender		
Male (0)	2973	45.90
Female (1)	3509	54.10
Missing	0	.00
Teacher gender		
Male (0)	1984	30.60
Female (1)	4458	68.80
Missing	40	.60
Time on homework (minutes)		
60 or less (1)	5030	77.6
61 or more (0)	1294	20.00
Missing	158	2.40
Time in tutorial (minutes)		
45 or less (1)	1719	26.50
46 or more (0)	4705	72.50
Missing	58	.90
Computer access		
Yes (1)	4532	69.90
No (0)	1928	29.70
Missing	22	.30
Own room		
Yes (1)	4109	63.40
No (0)	2348	36.20
Missing	25	.40
Parental education		
Post-secondary (0)	2068	31.90
Secondary and below (1)	3249	50.10
Missing	1165	18.00
Major of study		
Mathematics (0)	5236	80.70
Non-mathematics (1)	1206	18.60
Missing	40	.60

Bivariate relationships between variables were examined at each level. Table 4.33 presents the correlations among student (level-1) variables. It appeared from these analyses that level-1 predictor variables were uncorrelated from each other except how students liked learning mathematics with their self-confidence in learning mathematics, $r = .65$. At the teacher and classroom (level-2), a bivariate relationship was also examined for five predictor variables.

Table 4.33

Bivariate Relationships between Level-1 Variables for Thailand

Variable	1	2	3	4	5	6	7	8	9	10
1. Student gender	1.00									
2. Confidence in math	-.12	1.00								
3. Valuing math	.12	.29	1.00							
4. Liking math	-.03	.65	.05	1.00						
5. Enjoying math	.05	.13	.38	.31	1.00					
6. Time on homework	-.11	.15	.02	.10	-.05	1.00				
7. Time in tutorial	-.13	.04	-.07	.00	-.12	.27	1.00			
8. Computer access	-.04	-.01	.01	-.03	.01	.00	-.02	1.00		
9. Parental education	.04	-.04	-.01	.05	-.02	.02	.05	-.18	1.00	
10. Own room	.05	-.01	.03	.01	.01	.00	-.01	.10	-.03	1.00

Table 4.34 presents the correlation matrix for these variables. None of the level-2 variables was correlated to each other. To ensure tenability of results yielded by hierarchical linear modeling in this research, the assumptions of both level-1 and level-2 were verified congruently model buildings with the predictor variables. The descriptive statistics of both level variables presented an approximate normal distribution in combinations with their skewness and kurtosis values. The analysis also suggested that there was evidence of homogeneity of level-1 variance. The assumptions of normality and homogeneity of level-1 and level-2 random effects were satisfied.

Table 4.34
Bivariate Relationships between Level-2 Predictor Variables for Thailand

Variable	*1*	*2*	*3*	*4*	*5*	*6*
1. Teacher gender	1.00					
2. Years of experience	.10	1.00				
3. Major of study	-.06	-.04	1.00			
4. Job satisfaction	.11	.14	-.10	1.00		
5. Class size	-.12	.00	-.15	.00	1.00	
6. Number of computers	-.02	.01	-.10	-.06	.04	1.00

The unconditional model, in which none of the level-1 or level-2 predictor variables was included, was first built using Hierarchical Linear Modeling software *version* 7 (HLM *v*7). The fixed effect estimate of the intercept was 447.42 (*SE* = 6.08, *p* < .001). The average of mathematics achievement was significantly different across the classrooms in Thailand (τ_{00}= 6780.89, *SD* = 82.35, *p* < .001). Within classrooms, the amount of unexplained variance was smaller than the between classrooms (σ^2= 2844.60, *SD* = 53.33). The intra-class correlation (*ICC*) was then calculated using the formula,

$$ICC = \frac{\tau_{00}}{(\tau_{00} + \sigma^2)} = .70$$

The computed *ICC* of .70 represents the ratio of between-class variance and the total variance (within- and between-class variance) and indicated that 70% of the variance student mathematics achievement was between classes. That is, approximately 30% of the variance in student mathematics was attributed to student-level differences.

To answer the research questions, the student (level-1) variables (continuous and dummy coded variables) were added to the model to determine whether their relationship with student mathematics achievement varied significantly. Student background variables were entered and centered around the grand means. Table 4.35 presents the results random-coefficients model for each predictor variable along with the variance components of within and between classrooms.

Random effects were individually checked and tested for each level-1 variable using the likelihood ratio test within *HLM v*7, and none of the random slopes were found to significantly improve the model fits.

Table 4.35
Parameter Estimates for Thailand

Fixed Effects	Null model Estimate	*SE*	Random-Coefficients Model Estimate	*SE*	Full Model Estimate	*SE*
Intercept	447.42	6.09	448.07**	5.76	447.96**	5.65
Student-level						
Student Gender			2.00	1.62	1.95	1.61
Confidence in math			10.19**	0.64	10.18**	0.64
Valuing math			1.71**	0.49	1.71**	0.49
Liking math			5.15**	0.78	5.18**	0.78
Enjoying math			-0.16	0.51	-0.15	0.51
Time on homework			-4.51*	1.94	-4.51*	1.94
Time in tutorial			-11.51**	1.89	-11.50**	1.89
Computer access			-0.05	1.82	-0.20	1.81
Parental education			-9.26**	1.84	-9.12**	1.84
Own room			-14.97**	1.58	-14.92**	1.58
Classroom-level						
Teacher gender					4.31	12.76
Years of experience					-0.02	0.52
Major of study					-11.71	11.53
Job satisfaction					-5.34	3.65
Class size					-0.04	0.59
Number of computers					0.09*	0.03

Variance components	Null model Estimate	Random-Coefficients Model Estimate	Full Model Estimate
Student-level	2844.60	2312.57	2312.44
Classroom-level	6780.89	6069.71	5839.73

* $p < .05$.
** $p < .001$.

The full explanatory model was built by combining all student-level and classroom-level variables to predict mathematics achievement. According to the full model, statistically significant student-level predictors of mathematics achievement included confidence in learning mathematics, value in learning mathematics, like learning mathematics, time on homework and in tutorial, parental educational, and access to a computer at home. For each increase by 1 point in confidence in math, valuing of math, and liking math, mathematics achievement increased by an estimated 10.19, 1,71, and 5.15 points, respectively. This indicated that the average mathematics score of students who were more confident in, valued more, and liked more learning mathematics was predicted to increase, especially for those who had more confidence in learning mathematics. Students who spent more than 60 minutes on homework and more than 45 minutes in tutorial were predicted to score 4.51 and 11.50 points higher, respectively, on the mathematics achievement. Students who had access to a computer at home were predicted to score 14.92 points lower on the mathematic achievement than those who did not have. Likewise, students who had parental education with secondary education and below were predicted to score 9.12 points lower on the mathematics achievement than those who had parental education with post-secondary and above. When considering statistically significant of level-2 predictors of mathematics achievement, the average mathematics score was predicted to increase by each available computer increase in school; however, the estimate of the coefficient was too small (.09) to report.

Chapter Summary

In all seven APT countries in this study, missing data existed at both student level (level-1), and teacher and classroom level (level-2). Listwise deletion was being utilized in examining the influences of predictor variables upon mathematics achievement score. Using the descriptive statistics, differences in student level and classroom level were observed in the student mathematic achievement across the seven countries. A commonality observed in these seven countries was liking mathematics and being confident in learning mathematics. At the classroom level

(level-2), class size in the seven APT countries seemed to have, on average, above 30 students in each class. The examination of the bivariate correlations among the student level predictors (student gender, confidence in math, valuing math, liking math, enjoyment in learning math, time on homework and in tutorial, computer access, parental education and own room) and teacher/classroom level variables (teacher gender, years of experience, major of study, job satisfaction, and class size) suggested that these variables were not correlated with each other.

The examination of the unconditional models from seven APT countries suggested that the total variance in mathematics achievement scores occurred between classrooms. The unconditional, random-coefficients, and full models were built to examine the variances within and between classrooms for each country. Similarities and differences occurred when examining the set of student level and teacher/classroom level predictors of mathematics achievement. Table 4.36 presents the full model estimates for all seven APT countries.

Comparing the seven countries side by side, when considering statistically significant predictors at both level-1 and level-2, the average mathematics scores were still distinctive into two performing groups: low and high performance. Student gender had influenced the average mathematics achievement positively in Korea, and negatively in Malaysia and Singapore. Across all of the seven countries, student confidence in mathematics certainly increased the average mathematics score. Students' value of mathematics also helped explain the increase in average mathematics achievement in Chinese Taipei, Korea, Japan, and Thailand. Students' liking mathematics aided in explaining an increase in student performance in Hong Kong, Malaysia, Singapore, and Thailand. Students' enjoyment in learning mathematics dictated the increase in student achievement in Chinese Taipei, Hong Kong, Korea, Japan, Malaysia, and Singapore. Only in

Hong Kong and Thailand, time on homework and in tutorial had positively influenced the student performance. Students who had access to a computer at home actually performed lower than who did not have computer at home across six of the seven APT countries. Likewise, students who had their own room to study at home performed lower than who did not have room to study at home. Students whose parents with postsecondary in Hong Kong, Malaysia, Singapore, and Thailand achieved higher average mathematics score than those whose parents with secondary education and below.

At level-2, female teachers positively impacted student achievement in Hong Kong and Singapore. Teacher experience only increased student performance in Chinese Taipei by .75 point while the rest of the countries saw no impact. Korean students increased their average mathematics score by having teachers who did not have a mathematics major. The results also presented that teacher job satisfaction positively increased student performance in Chinese Taipei and Hong Kong. Class size positively impacted student performance in two of the seven countries (Hong Kong and Singapore) while the number of available computers impacted student achievement in four of the seven countries (Japan, Malaysia, Singapore, and Thailand) with a small estimate (.81, .12, .07, and .09, respectively).

Chapter 5 was followed up to discuss the results for each country and a comparison of all seven countries situated in the literature and the research questions.

Table 4.35

Parameter Estimates for All Seven APT Countries

	Chinese Taipei		Hong Kong		Korea		Japan		Malaysia		Singapore		Thailand	
Fixed Effect	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	604.15**	2.41	584.56**	4.68	605.20**	1.72	586.72**	2.93	502.79**	4.34	604.15**	2.41	447.96**	5.65
Student-level														
Student Gender	1.77	2.27	1.64	1.57	9.25**	2.52	-0.41	2.19	-6.72**	1.09	-2.48*	1.01	1.95	1.61
Confidence in math	17.37**	0.75	10.14**	0.48	19.92**	0.74	18.67**	0.82	12.43**	0.46	7.39**	0.30	10.18**	0.64
Valuing math	3.46**	0.85	-0.53	0.48	5.83**	0.76	3.22**	0.84	-0.13	0.36	-0.40	0.32	1.71**	0.49
Liking math	-0.07	0.95	3.05**	0.61	-0.89	0.88	0.45	1.08	2.31**	0.54	1.56**	0.38	5.18**	0.78
Enjoying math	3.25**	0.58	1.09*	0.40	4.32**	0.63	1.99*	0.72	-2.91**	0.32	0.74*	0.24	-0.15	0.51
Time on homework	5.17	4.00	-5.34*	2.47	1.31	4.07	3.45	4.31	0.96	1.39	-1.46	1.26	-4.51*	1.94
Time in tutorial	0.40	2.08	-4.68*	1.81	3.87	2.43	0.98	2.45	1.27	1.24	2.22	1.21	-11.50**	1.89
Computer access	-13.46**	1.87	-5.54**	1.56	-16.84**	1.99	-9.70**	2.16	-2.07*	1.05	-3.18**	0.99	-0.20	1.81
Parental education	-0.10	2.32	-4.68*	1.74	-20.71**	2.04	-2.56	2.34	-2.72*	1.11	0.06	1.02	-9.12**	1.84
Own room	-5.96**	2.02	-4.93*	1.57	-0.19	2.20	-1.69	2.90	-6.59**	1.09	-2.94*	0.93	-14.92**	1.58
Classroom-level														
Teacher gender	0.61	5.16	27.28*	9.48	-1.84	3.93	-4.23	20.81	-0.30	10.57	25.30*	8.01	4.31	12.76
Years of experience	0.75*	0.32	0.49	0.51	-0.24	0.18	0.46	0.26	-0.12	0.54	0.15	0.46	-0.02	0.52
Major of study	0.24	4.78	-6.17	11.81	71.10*	33.88	-2.77	13.97	-16.25	9.69	7.19	8.40	-11.71	11.53
Job satisfaction	1.45**	1.17	6.11*	2.59	1.00	0.87	-0.37	1.57	2.86	2.63	2.56	1.77	-5.34	3.65
Class size	3.36	0.36	4.43**	0.70	0.20	0.17	0.48	0.42	-0.08	0.57	1.55*	0.59	-0.04	0.59
Number of computers	0.09	0.05	0.09	0.06	-0.04	0.04	0.81**	0.13	0.12*	0.05	0.07*	0.03	0.09*	0.03

Variance Component	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
Student-level	4009.91	1704.20	3862.79	4040.18	1429.65	813.37	2312.44
Classroom-level	876.68	2554.67	340.64	1031.29	5117.03	4720.23	5839.73

* $p < .05$

** $p < .001$

5 DISCUSSION

This chapter deliberates the purpose of the study, reviews the research questions, addressed the limitations of the study, summarized the findings of the analyses, provides the interpretations of the findings and discuss the overall results situated in the literature, and, last but not least, concludes with recommendations for further research.

Conclusions

The purpose of this study was to examine the influences of student and classroom related background variables on eighth-grade mathematics achievement in ASEAN+3 (APT) countries that participated in the TIMSS 2015 eighth-grade mathematics assessment. For each country, a sets of two-level models were constructed to examine the scope to which student background, home resources, teacher and classroom background-related variables were associated with TIMSS 2015 eighth-grade mathematics achievement scores. Eventually, the overarching goal for this research was to provide empirical evidence (if any) to support the perspectives that different countries have different educational models that may work for one country but not the other. Although selected and examined countries were in the same geographical region, there were few countries that performed at the top, and there were others that performed at the lower end. Having said that, different countries had their distinctive characteristics and factors that impact student learning; hence, it is impossible to implement what works in one country to another (Bryan *et. al.*, 2007; Delaney, 2000).

Since TIMSS 2015 data naturally occurred as clusters, multilevel models were utilized to apprehend the relationship among the student and teacher/classroom variables and eighth-grade student mathematics achievement. More specifically, unconditional, random-coefficient, and full models were constructed to illustrate the student level (level-1) and teacher/classroom level (level-2) in the TIMSS 2015. As for all HLM analysis, the unconditional model or baseline model which none of the level-1 or level-2 variables was added. Random-coefficient model was created by adding each individual student level into the baseline model to determine whether or not which predictors were statistically significant in explaining the differences in the average mathematics achievement scores. Then, a full model was created to include each individual teacher/classroom level variables (level-2) along with level-1 predictors. For ease of comparisons among the seven countries, cross-level interactions were not allowed among the predictors. Statistical significances would then be noted for the interpretation of the analyses.

The constructions of the baseline models for the seven APT countries found to be similar in their ICCs calculation. The smallest ICC was .10 (Korea) while the largest ICC was .83 (Singapore). Approximately, variances in mathematics achievement scores in these seven countries varied and presented a wide gap between classrooms. Of the seven APT countries, the high performance countries such as Hong Kong and Singapore presented a high ICC values, .63 and .83, respectively while Malaysia and Thailand, low performance countries, also showed a high ICC values, .75 and .70, respectively. There is a possible response to this similar ICC among these countries because they are geographically close to each other, and some even share the same cultural capital and traditions among themselves. Moreover, the high performance countries are more developed in terms of economics. Hence, they may perceive education in a very similar direction.

Student background model (random-coefficients model) was constructed in attempting to answer the first two research questions in terms of to what extent eighth-grade mathematics achievement was influenced by student background and home resources variables, including student gender, student self-confidence in learning mathematics, liking mathematics, valuing in learning mathematics, enjoying learning mathematics, time spent on homework, time spent in tutorial, computer access and own room to study at home, and parental educational level. The results suggested that this student background and home resources model worked similarly across seven countries. It is worth noting that student confidence, valuing, liking and enjoyment in learning mathematics, in fact, partially explained the differences in the student mathematics achievement score in TIMSS 2015.

In connecting to existing literature (Neuschmidt et al., 2008), the results from Korea, Malaysia, and Singapore supported the view that gender gap existed in mathematics achievement among the seven countries. More specifically, female students tended to perform higher than male students in Korea and Singapore while it was the opposite in Malaysia. Student self-confidence analysis in the random-coefficients models was found to significantly imcreased the average mathematics score across the seven APT countries. The findings were also in line with the existing literature (House, 2003) and again confirmed his assertion that those who enjoyed learning mathematics and believed mathematics was important tended to perform higher than others.

Four out of seven participating countries, students who valued in learning mathematics performed higher than those did not. More specifically, students who reported that they valued learning mathematics in Chinese Taipei, Korea, Japan, and Thailand performed higher, on average, in mathematics. It is worth noting that of those four countries, student liking in learning mathematics showed no significance in impacting the mathematics achievement. However, of those three countries (Hong Kong, Malaysia, and Singapore) whereas student valuing mathematics had no impact on the achievement, but student liking in learning mathematics showed a significant impact. As for student enjoyment in learning mathematics, five countries (Chinese Taipei, Hong Kong, Korea, Japan, and Singapore) presented a positive gain in mathematics score, Malaysia showed a deduction, and Thailand had no significant impact. In terms of the current literature (House 2003), the findings once again were in line with the assertion that those who enjoyed learning mathematics and believed mathematics was important tended to perform higher than others.

Student home resources in the random-coefficients models also helped address the second research question regarding the influences between eighth-grade mathematics achievement scores and student computer access, parental educational level, and having own room to study. In terms of having access to computer at home, the analyses suggested a negative impact on the average mathematics performance all across seven countries. Korea saw the most impact (-16. 84 points) from this predictor (computer access) among the countries while Thailand had the least impact (-.20 points). Of the seven APT countries, Hong Kong and Thailand showed a significant impact of how much time students spent on homework and in tutorial upon their mathematics achievement score. Specifically, the results from the analyses suggested that students who spent less than 60 minutes on home work and less than 45 minutes in tutorial would perform lower than who spent more than 60 minutes on home work and more than 45 minutes in tutorial. Students whose parents had postsecondary education achieved higher score in mathematics than whose parents just had secondary education and below in Hong Kong, Korea, Malaysia, and Thailand. The most impacted on the mathematics achievement was observed in Korea (-20.71 points). In terms of the existing literature (Baker, Goesling, & LeTendre, 2002; Crane, 2001; O'Dwyer, 2005; Veenstra & Kuyper, 2004; White, 1982; Yang, 2003; Nyarko, 2010), the results once again suggested the findings were in line with the previous research.

The full explanatory model was created to address the variances within and between classrooms taking into accounts of the teacher background variables. In combination of the random-coefficients model, this full model aimed at addressing the last two research questions in terms of to which extent teacher and classroom characteristics, including teaching gender, years of experience, major of study, job satisfaction, class size, and number of available computers influence eighth-grade mathematics scores from TIMSS 2015 across the seven countries. In Hong Kong and Singapore, teacher gender was found significantly related to student performance. Explicitly, students who had female teachers would perform higher than those who did not. In terms of teacher experience, only Chinese Taipei saw a .75 point gain in student achievement while the other six countries saw no significance. It is interesting to see that students in Korea who had teachers with no major in mathematics would score a 71 points increase as compared to others. Teacher job satisfaction also helped explain the differences at level-2 in Chinese Taipei and Hong Kong whereas there was no significance observed in other five APT countries. Although class size, on average, above 30 students in the seven APT countries, only Hong Kong and Singapore showed a significant impact upon student mathematics achievement. Although the number of available computers showed a significant impact in Japan, Malaysia, Singapore and Thailand, the student mathematics achievement showed a minimal increase (.81, .12, .07, and .09, respectively). In connecting to the existing literature, Shin and Radenbush (2011) affirmed that reducing class size would increase student achievement in reading, mathematics, and listening in K-3 setting.

Despite the differences in economic development status, political systems, technologies advanced, and education systems, ASEAN+3 countries share common traditional cultures among themselves. Historically, Singapore was one of the 14 states of Malaysia in the sixties for a short period of time (Singapore Government). Japanese and Korean history can be dated back to when they were once Chinese territories. Chinese Taipei and Hong Kong have been provinces of China although they have effortlessly worked toward their independency in the recent years. Thailand has remained neutral and has not been tampered by any other cultures or traditions. Having said that, countries of the ASEAN+3 "share a common vision for an ASEAN community" (UNESCO, 2014).

ASEAN+3 countries, as a whole, have determined that education policies play a pivotal role in transforming the educational landscape in the region as well as the learning outcomes. The political leaders have agreed that a successful transformation in education include educational policy reform efforts that are guided by a clear vision, implemented with fidelity, managed and monitored effectively and continuously. ASEAN+3 countries have ratified the Convention of the Rights of the Child (UNESCO, 2014) which is to provide free primary education of all children. This is an important regulation that outlines "what, how and when citizens of a country should exercise their rights to education." It is worth noted that the duration for free and compulsory primary education is six years in Republic of Korea and Singapore while upper secondary education is free of charge, but not compulsory, in Malaysia and Japan.

Hong Kong, Japan, and Singapore have been top performers among the participated countries in TIMSS assessments. Analyses in the previous section revealed no major differences using the same student and teacher/classroom variables. As Leinwand and Ginsburg (2007) wrote, the Singapore mathematics curriculum concentrated with problem-solving in the middle and the other skills to support learning. In 2010, Hui and Lau investigated the policies and development of education in Chinese Taipei, Hong Kong, and Singapore. Both authors affirmed that these educational system focus on thinking skills, creativity, and encouragement in the classroom. Moreover, these skills were found to be embedded in general skills, innovation, artistic skills, visual arts, and cultural heritage.

Issues of equity and access to education have been a challenge to majority of the countries around the globe. Being a member of APT+3 and working toward the ratified Convention of the Rights of the Child, each individual country faces its own issues in terms of educational access and equity. The most common finding among the seven countries was not about the student performance nor what influenced the achievement, but rather the disparities in human development geographically. Each individual country or territory urbanizes and develops differently; hence, forcing the development of more centralized and better education in the city as compared to the rural areas.

In terms of social justice issues in mathematics classrooms, many studies have found that Singapore textbooks and content related were ranked highest among the neighbor countries (Fan & Zhu, 2007; Hoven & Garelick, 2007; Yang, Reys, & Wu, 2010). The authors found that Singapore mathematics textbooks had various levels of questions in which social justice issues were embedded. By having and providing multiple levels of questions really allowed every student the opportunity to complete the material, to learn the concepts, and to reach their goals that is appropriate to their learning ability. However, Singapore's education system comes with a highly differentiated system (OECD, 2011). In other words, there still exists the practice of tracking and streaming to differentiate students who comes in with different abilities at various transition points. Weis (2010) believed that by practicing tracking and streaming system, Singapore really differentiates knowledge and credentials through school curriculum. Hence, education inequality occurs within the system by reinforcing the unequally distributed cultural and social issues among the learners. As Swartz (1997) stated, this practice legitimized social inequalities by excluding equal educational opportunities as well as occupational and economic outcomes. Ng (2011) wrote,"

> [… Singapore's education] system remains differentiated, putting students of different academic caliber into different tracks in different kinds of schools where their social lives do not mix up. When translated into earnings, the greater the wade premium placed on the qualifications of the 'skilled' verses the 'technical', the further behind the earnings of the lower-skilled will trail. These tensions [between various 'actors' in the 'field'] are difficult knots to disentangle. Singapore's small and vulnerable economy necessitates a competitive education system to produce a competitive workforce. […] Unfortunately, such a system also has detrimental effects on mobility. (p.????_)

Hong Kong education system was also worth taking a look at. When students were interviewed, their responses were divided into two groups: (1) the curriculum is not engaging, and (2) the assessment is rather invalid and inequitable (Chang, 2018). The author believed that both topics needed to be addressed in order to achieve the educational equality. When being interviewed in Chang (2018), Charles stated, "*The curriculum isn't engaging to an extent … Some teachers try to get the motivation up, but the core issue is that it isn't addressing what society really needs*." On the other hand, Mona responded to curriculum related questions, "*The exams here are strange … While they are efficient and check students' knowledge swiftly, they put too much effort on reciting back information and don't help much for students' generic skills like creativity, critical thinking, and also for their future studying.*" Having written, there exists a problematic curriculum in Hong Kong education system in which compulsory exams determine curriculum to be not engaging and lack of social aspects. This created "teaching to the test" and was considered as one of the main reasons why Hong Kong schooling systems continues or exacerbates inequities among the students.

Japanese education system mirrors with Singapore in tracking students' abilities (Stevenson & Nerison-Low, n.d.). The authors believed that tracking during the elementary and junior high school years created a separated learning community among students in terms of ability and equality. When being interviewed, one of the teachers thought, "*If a school separated students according to ability differences, what the school is doing is discriminating among students. This goes against the school's basic goal of having students learn as members of a group*."

Overall, social justice issues and inequalities still exist in part of the Asian countries, especially ASEAN+3, students in Chinese Taipei, Hong Kong, Japan, Republic of Korea, and Singapore perform well beyond average. Unlike United States or other nations, student population in these ASEAN+3 countries remain as homogenous group which means that there is no racial segregation within and between classrooms and schools. The possible issue with which many schools face is student's social-economic status and any other related factors. For the purpose of this study, social-economic status and other related factors were not explored to examine the impact upon student achievement. This could be done in the future study to fully investigate the effect of social-economic and social justice issue on student performance.

Since the student body in these seven APT countries was more homogenous as compared to the student body in United States or any other country, the discussion of this study will attempt to be situated in cultural capital issue. The term "cultural capital" was stemmed from Bourdieu (1973, 1977) as "an emphasis on the differential exposure to cultural resources (attitudes, knowledge, behavior, modes of appreciation) that can be used to obtain access to other valued social resources” (as cited in Pavie, 2016, p. 1). In other words, Bourdieu’s cultural capital claimed that children from the upper social class tend to perform better and succeed in school as compared to those who came from the lower class because of the exposure to high status culture that allowed them to be awarded with higher cultural capital (Byun, Schofer, & Kim, 2013).

According to Byun et al. (2013), the concept of cultural capital has widely been introduced to the East Asia. For example, Yamamoto and Brinton (2010) investigated the role of cultural capital in Japan. The authors found that student achievement was, in fact, positively influenced by home possessions as related to high status culture and the participation in cultural activities and reading by parents. It is noteworthy to say that many Korean parents spend lots of money sending their children to educational activities outside of formal schooling (Stevenson & Baker, 1992; Park, Byun & Kim, 2011). Because of the intensifying for test preparation inside and outside school and highly competitive setting in schools, students who excessively participate in high culture may have less time for test preparation, and consequently, student achievement may negatively be impacted (Byun, 2007; Byun & Kim, 2008).

Although this study utilized a highly reliable database and sophisticated statistical analyses, HLM, the analyses, results, findings, and interpretations are embodied with limitations in mind. TIMSS itself is an observational study; hence, the effects of the predictors estimated in level-1 and level-2 should not be interpreted as casual relationships because of the inability to determine the extent to which randomized assignment differences in student populations might have any effects on the estimated effects. Although the limitations existed, the findings were somewhat consistent with other findings in the previously reported literature.

Implications

Although limitations exist within the scope of the study, this research contributes a partial answer to the field of educational research and measurement. It was an attempt to diminish the bias in international educational research by examining the influences of mathematics achievement in top performance and low performance countries. It was also an effort in inspecting the influences of student background, teacher background, and classroom characteristics as related to student mathematics achievement. The main focus of this study was for national leaders, educational agency, policy makers, and educators to have an insightful picture of how countries which are geographically close to each other also divided in student performance. Of course, last but not least, the findings of this study may help provide the existence of evidences that indicate multiple interrelated correlation supporting the perspectives that different countries have different educational models that may work for one country but not the other even though they share common cultural capital.

Sternberg (2017) mentioned that less sharing of culture in geographically close countries and the existence of nonporous borders in the recent years have helped explain why Singapore students performed so well on the TIMSS assessment as compared to other surrounding countries. Education system in Singapore presents four different schools systems after elementary schools with various requirements related to skills and knowledge levels. Because of these differences, the Singapore students focus more on what they want to learn as compared to what being implemented from the government. On the other hands, Japan and Korea, composed of islands and located close to each other, focus more on test preparation and exams. For this reason, student achievement on TIMSS has been the top performers over the years. Education system in these seven APT countries presents a valued discipline that is reflected in how teachers are selected and recruited into teaching (Quek et al., 2008). Having said that, student performance in mathematics indicates improvement in STEM education within the top performance countries.

Suggestions for Further Research

As a result of this research, several other future research can be conducted. A different set of countries in different region can be used to construct HLM models using TIMSS 2015 or other data means. As for the variances across countries, different countries can be selected in analysis so that the variances are being maximized. TIMSS databases consist of several important collected information; at the same time, PRILS and PISA also have a wide range of information that future research can be explored. Of course, a different set of student level, teacher/classroom level, and school level variables can be chosen in analyzing the influences as related to mathematics achievement or science achievement.

It is valuable to conduct a study where fourth-grade students take the TIMSS mathematics assessment, then four years later, they would take the TIMSS assessment again in eighth-grade. This longitudinal study will allow an examination of changes in student- and teacher/classroom-related background to student mathematics achievement. Another venue would be to analyze the past TIMSS database for the same set of countries as well as the next up-coming TIMSS administration in 2019. Furthermore, future research could use different student and teacher related background variables and situated in “cultural capital” as defined by Bourdieu (1973, 1977). As always, student gender and socio-economic status in combination with “cultural capital” would help to understand the notions of the differences in student achievement and help educational and policy leaders to enhance access and equity in the field of education.

In addition, the analyses of how student and teacher/classroom related variables influenced the student mathematics achievement score utilizing the multilevel modeling approach in TIMSS 2015. The findings addressed a set of four research questions in terms of to what extend these predictors impacted the student performance in these seven APT countries. It would be more interesting to seek the answers in terms of why these predictors had such influences upon the student achievement. For that reason, a qualitative component, including but not limited to student and teacher interviews, classroom observations, and country case study, in combination with this quantitative approach (HLM) in future studies will fully give meanings of what these predictors have impacts upon student achievement and why they behave in such cases.

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APPENDICES

Appendix A

INSTITUTIONAL REVIEW BOARD

Mail: P.O. Box 3999
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In Person: Dahlberg Hall
30 Courtland St, Suite 217

Georgia State University

October 12, 2017

Principal Investigator: Iman Chahine

Key Personnel: Chahine, Iman; Nguyen-Quan, Michael; Tinker Sachs, Gertrude, PhD

Study Department: Middle Sec Educ & Instruc Tech, Georgia State University, Middle & Secondary Education

Study Title: TIMSS 2015: Influences of Student and Classroom Related Background Variables to Eighth-Grade Mathematics Achievement in ASEAN+3 (APT) Countries

Submission Type: Exempt Protocol Category 4

IRB Number: H18148

Reference Number: 346695

Approval Date: 10/12/2017

Expiration Date: 10/11/2020

The above referenced study has been determined by the Institutional Review Board (IRB) to be exempt from federal regulations as defined in 45 CFR 46 and has been evaluated for the following:

1. determination that it falls within one of more of the six exempt categories allowed by the institution; and
2. determination that the research meets the organization’s ethical standards

If there is a change to your study, you should notify the IRB through an Amendment Application before the change is implemented. The IRB will determine whether your research protocol continues to qualify for exemption or if a new submission of an expedited or full board application is required.

Exempt protocols must be renewed at the end of three years if the study is ongoing. When the study is complete, a Study Closure Form must be submitted to the IRB.

Any unanticipated/adverse events or problems resulting from this investigation must be reported immediately to the University Institutional Review Board. For more information, please visit our website at www.gsu.edu/irb.

Sincerely,

Susan Vogtner

Susan Vogtner, IRB Member

Federal Wide Assurance Number: 00000129

Appendix B

Related Variables	Questions
Student Background Variables	1. Are you a girl or a boy? 2. Do you have any of these things at your home? Your own room 3. What is the highest level of education completed by your mother (or stepmother or female guardian?) 4. What is the highest level of education completed by your father (or stepfather or male guardian)? 5. How much do you agree with these statements about learning mathematics? I enjoy learning mathematics 6. How much do you agree with these statements about learning mathematics? I wish I did not have to study mathematics 7. How much do you agree with these statements about learning mathematics? Mathematics is boring 8. How much do you agree with these statements about learning mathematics? I learn many interesting things in mathematics 9. How much do you agree with these statements about learning mathematics? I like mathematics 10. How much do you agree with these statements about learning mathematics? I like any schoolwork that involves numbers 11. How much do you agree with these statements about learning mathematics? I like to solve mathematics problems 12. How much do you agree with these statements about learning mathematics? Mathematics is one of my favorite subjects 13. How much do you agree with these statements about mathematics? Mathematics is more difficult for me than for many of my classmates 14. How much do you agree with these statements about mathematics? Mathematics is not one of my strengths 15. How much do you agree with these statements about mathematics? I learn things quickly in mathematics 16. How much do you agree with these statements about mathematics? Mathematics makes me nervous 17. How much do you agree with these statements about mathematics? I am good at working out difficult mathematics problems 18. For how many of the last 12 months have you attended extra lessons or tutoring? Mathematics 19. During the last 12 months, have you attended extra lessons or tutoring not provided by the school in the following subjects? Mathematics

	20. When your teacher gives you homework in the following subjects, about how many minutes do you usually spend on your homework? Mathematics
	21. When your teacher gives you homework in the following subjects, about how many minutes do you usually spend on your homework? Mathematics
	22. How much do you agree with these statements about mathematics? It is important to do well in mathematics
Teacher Variables	23. By the end of this school year, how many years will you have been teaching altogether?
	24. Are you female or male?
	25. During your <post-secondary> education, what was your major or main area(s) of study? Mathematics
	26. During your <post-secondary> education, what was your major or main area(s) of study? Education–Mathematics
	27. During your <post-secondary> education, what was your major or main area(s) of study? Education–General
	28. During your <post-secondary> education, what was your major or main area(s) of study? Other
	29. How often do you feel the following way about being a teacher? I am content with my profession as a teacher
	30. How often do you feel the following way about being a teacher? I am satisfied with being a teacher at this school
	31. How often do you feel the following way about being a teacher? I find my work full of meaning and purpose
	32. How often do you feel the following way about being a teacher? I am enthusiastic about my job
	33. How often do you feel the following way about being a teacher? My work inspires me
	34. How often do you feel the following way about being a teacher? I am proud of the work I do
	35. How often do you feel the following way about being a teacher? I am going to continue teaching for as long as I can
School Variable	36. How many computers (including tablets) does your school have for use by <eighth grade> students?